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THE BRITISH JOURNAL OF METALS

Vol. 64 No. 386 DECEMBER, 1961 Monthly: Two Shillings and Sixpence

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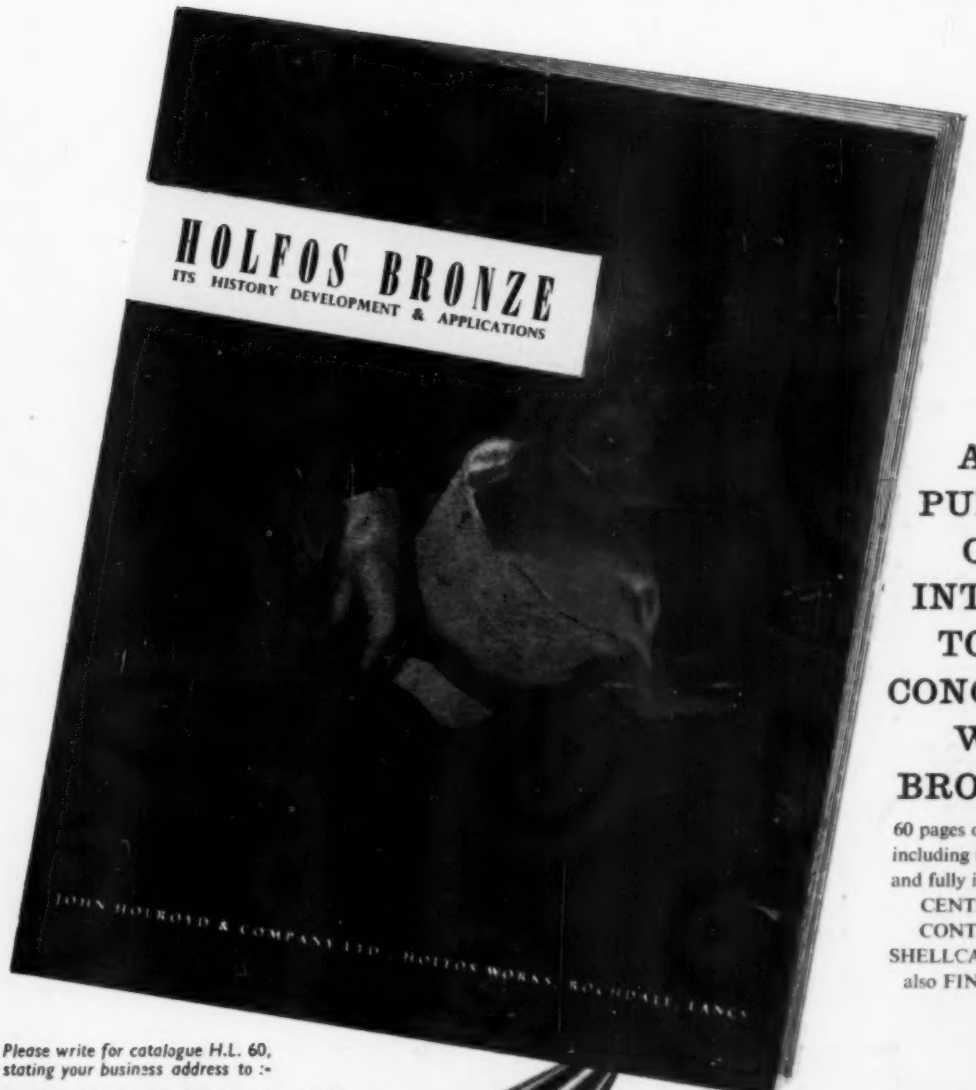

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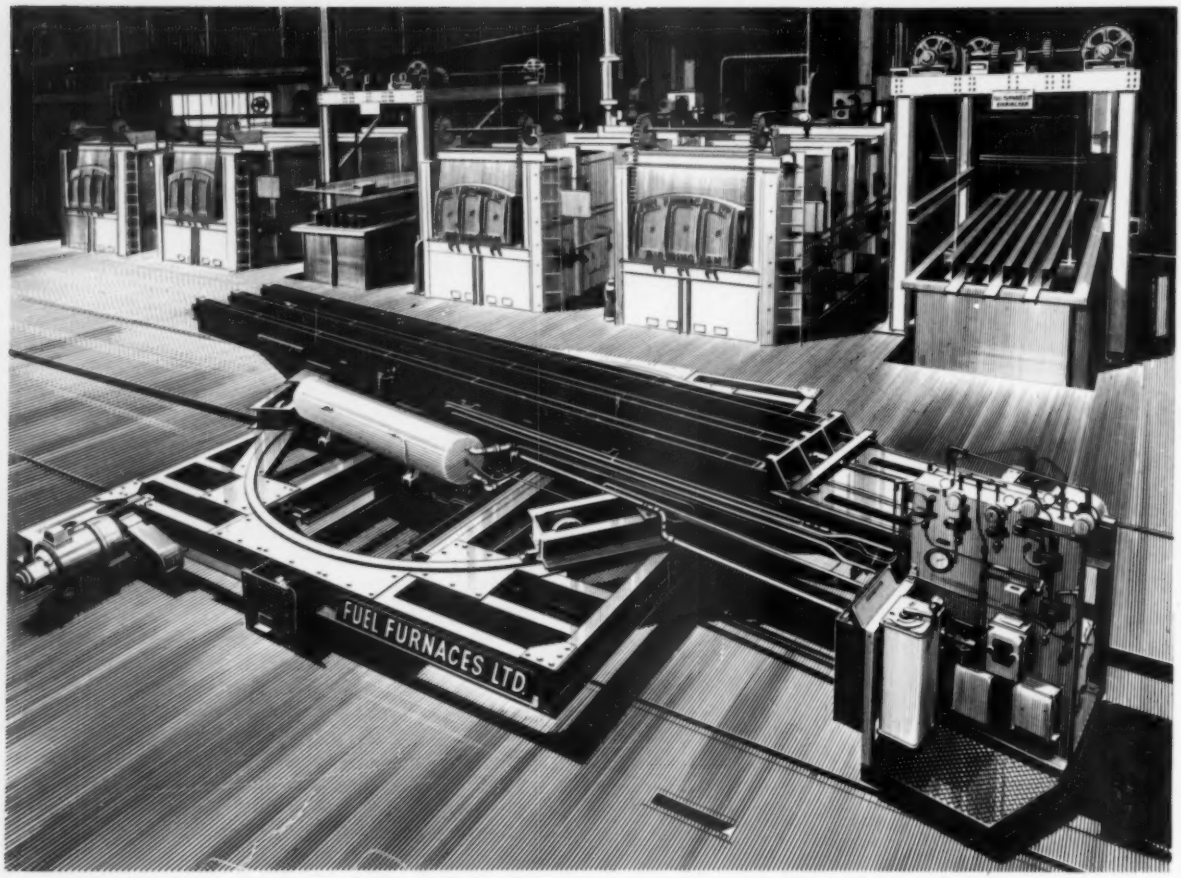

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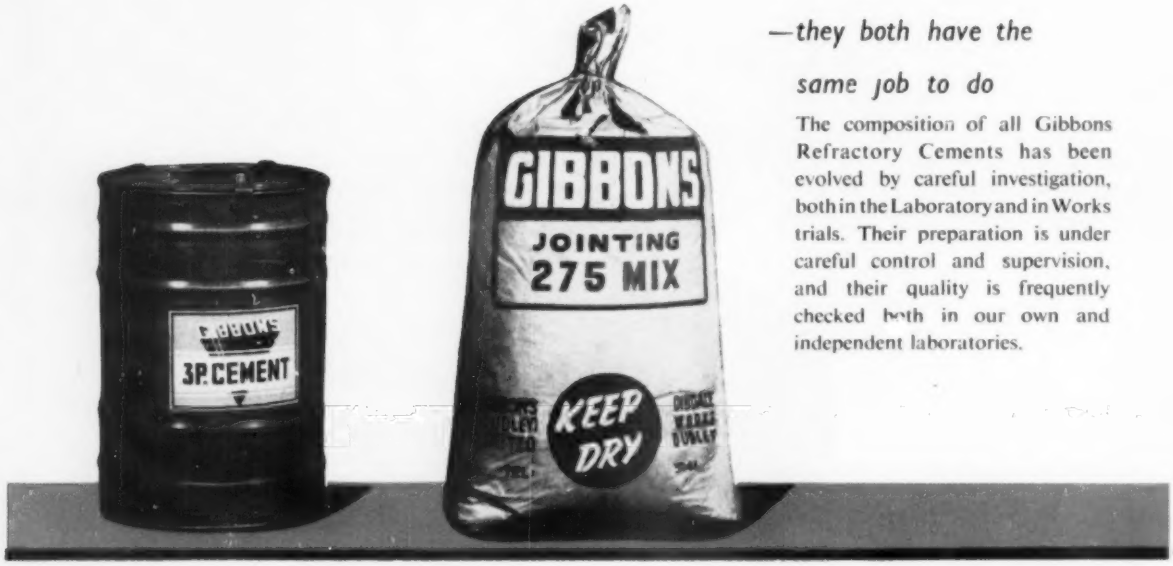

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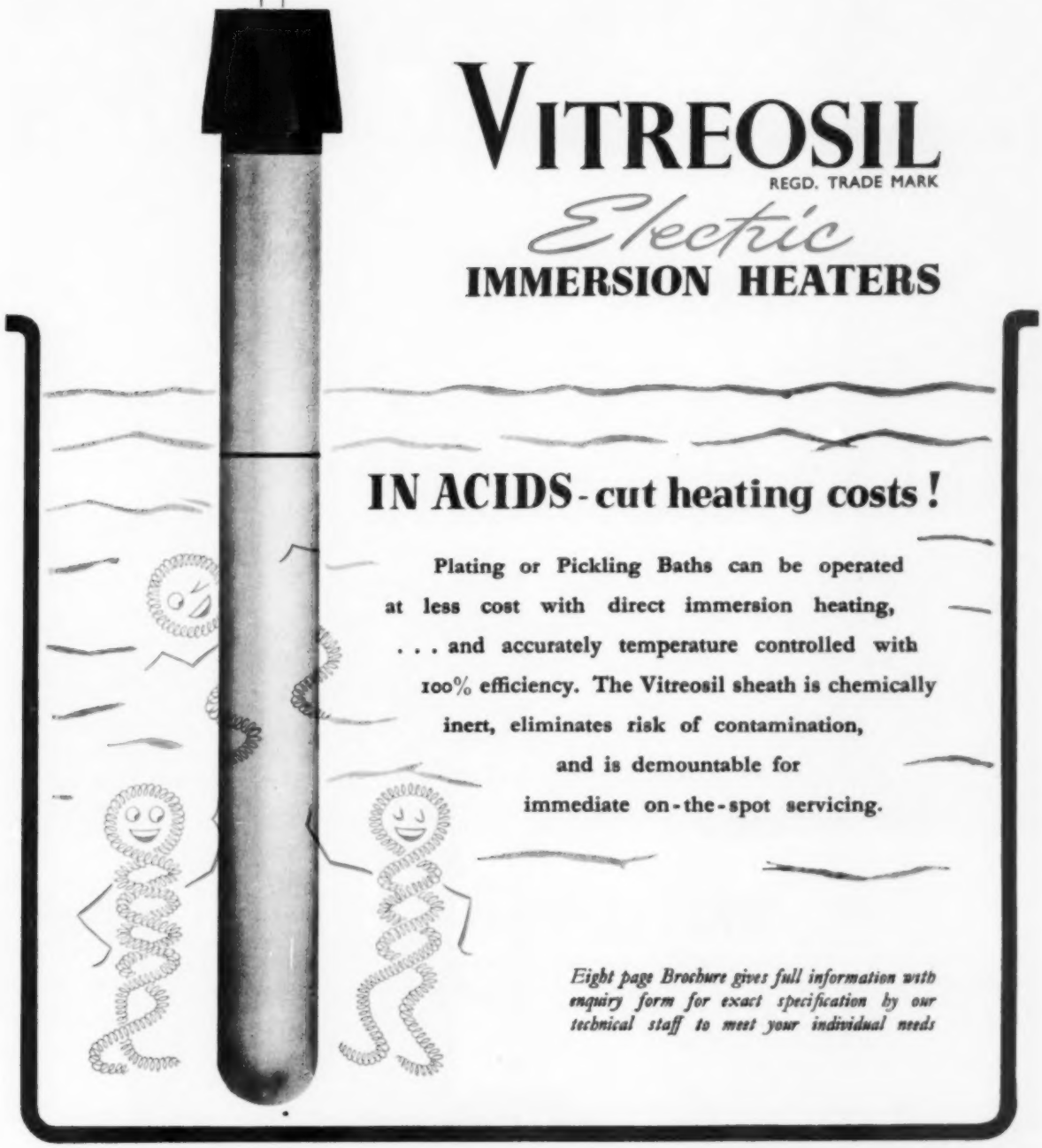

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Stein 73 Plastic	Plastic			+ 1750°C	1000°C	1800°C	180	2884
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Stein Carome Patch	Semi-Plastic			+ 1750°C	600°C	1500°C	200	3204
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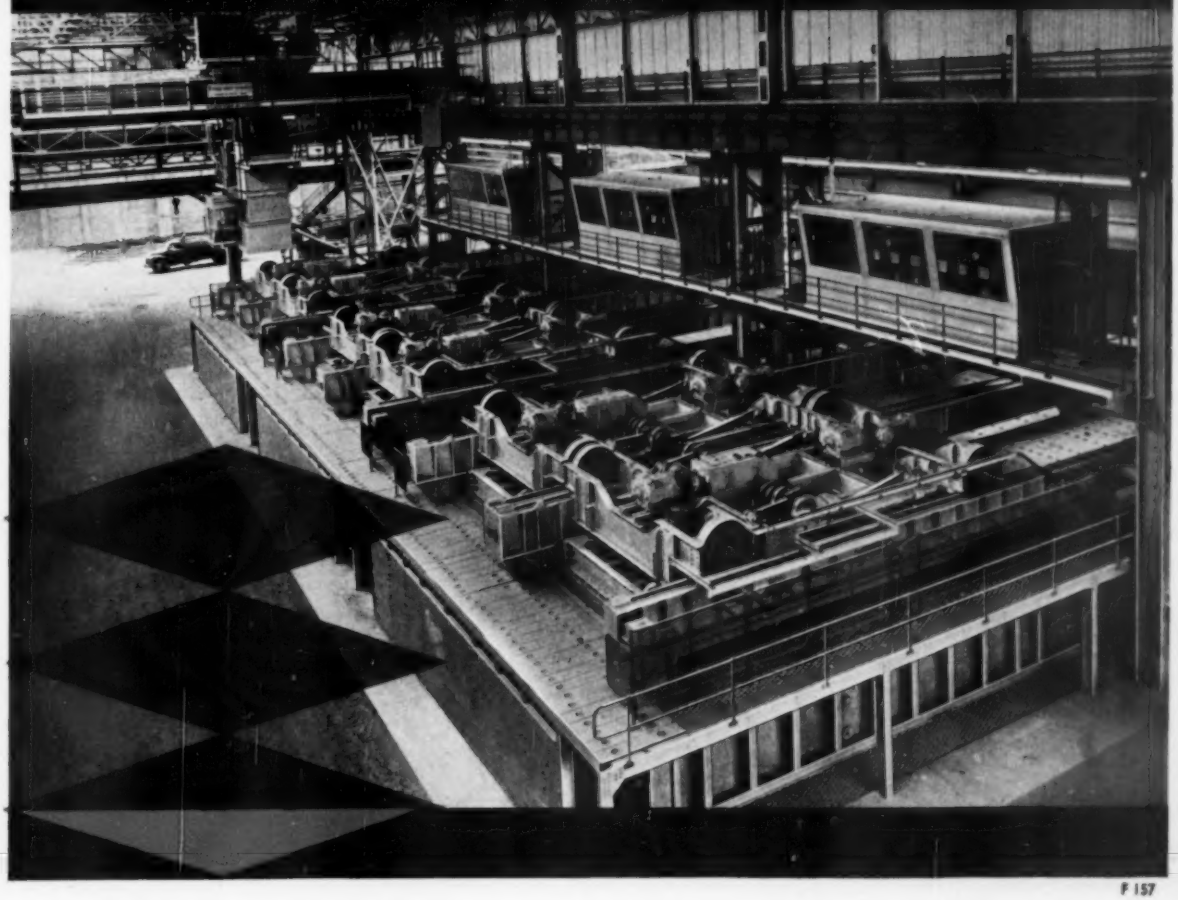

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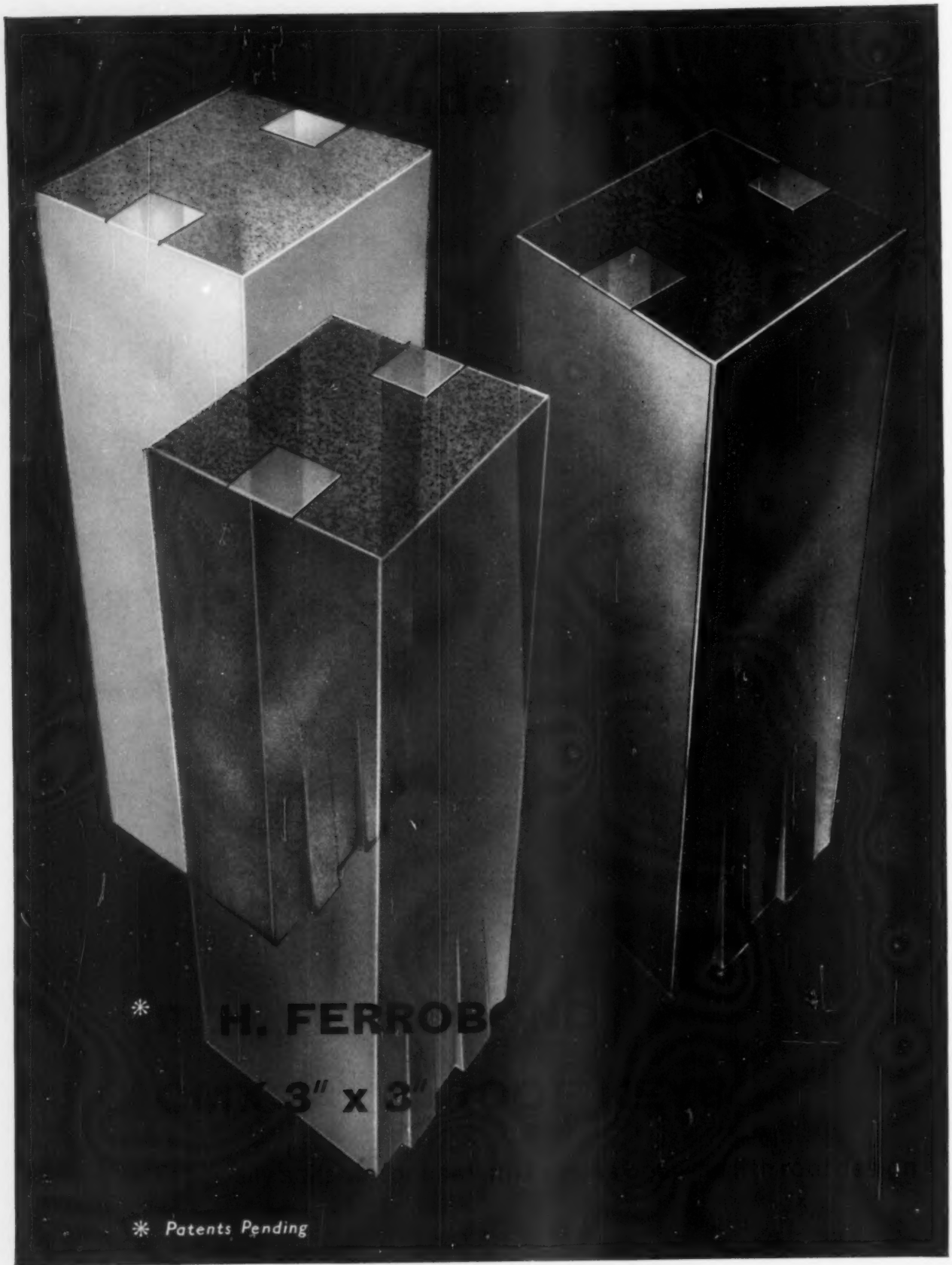

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Furnace Capacity	Construction of Roof	Campaign Life	Total Tonnage Produced	Tons/ Hour	% AREA PATCHED		Oxygen Lances through Roof
					Lavino Ferrobond CMX 3" x 3" Keys	Metal Cased Internally Reinforced 4½" x 3" Keys	
190 Tons	12" Rib 9" Valley	284 Heats 112 Days	54,000 Tons	20	1.0%	1.6%	2
190 Tons	12" Rib 9" Valley	250 Heats 75 Days	47,500 Tons	26	2.2%	12.6%	2
190 Tons	All 12"	405 Heats 139 Days	77,000 Tons	25	62%	67%	2
200 Tons	15" Rib 12" Valley	488 Heats 196 Days	100,000 Tons	21	2.8%	6.6%	NONE
345 Tons	15" Rib 12" Valley	453 Heats 170 Days	157,000 Tons	38.5	10.4%	19.0%	2
400 Tons	15" Rib 12" Valley	298 Heats 186 Days	120,000 Tons	27	NIL	NIL	2

This chart shows comparative performance records in North America of six typical open hearth roofs. In each case the roof was constructed half-and-half of Lavino Ferrobond CMX 3" x 3" Roof Keys and Internally Plated 4½" x 3" Roof Keys. All were of the Fairless type roof construction (hold-up, hold-down). Production rate of tons per hour is based on total production over campaign time, and includes repair times, fettling times, and all lost time whatever the cause.

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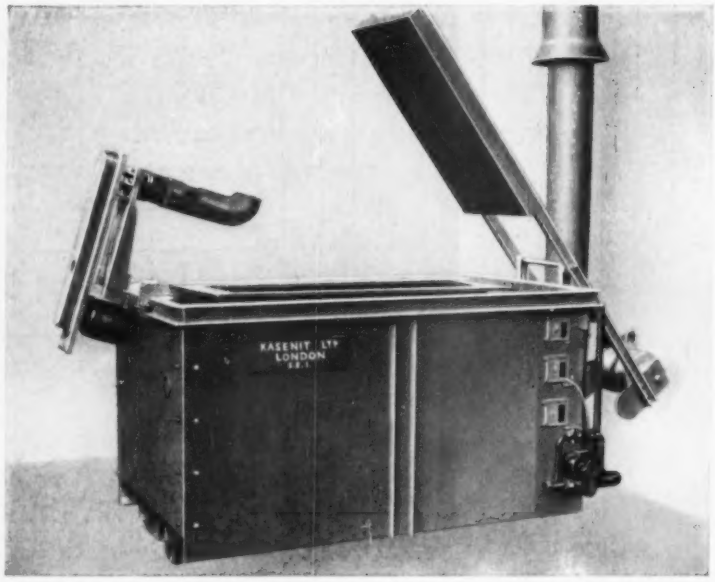

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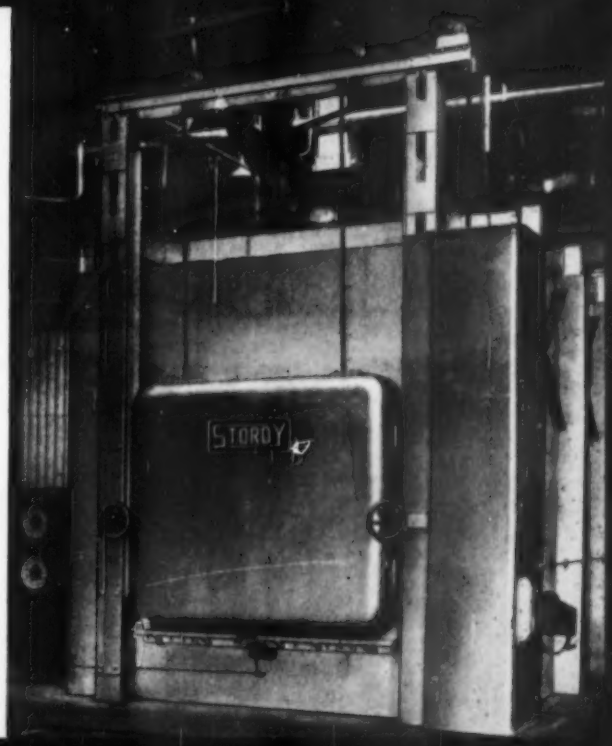
Illustration: Electrically heated, air circulated batch-type furnace for aluminium. Working temperature 600°C. Heated length 20' 6".



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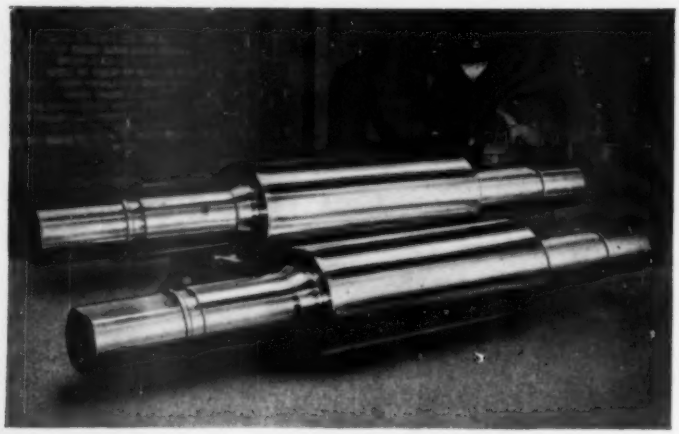

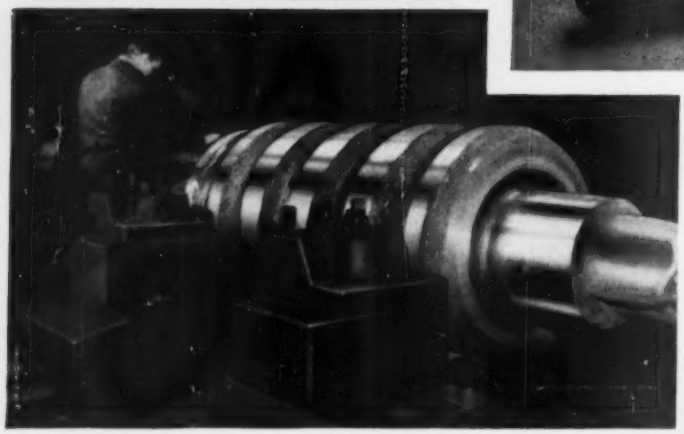

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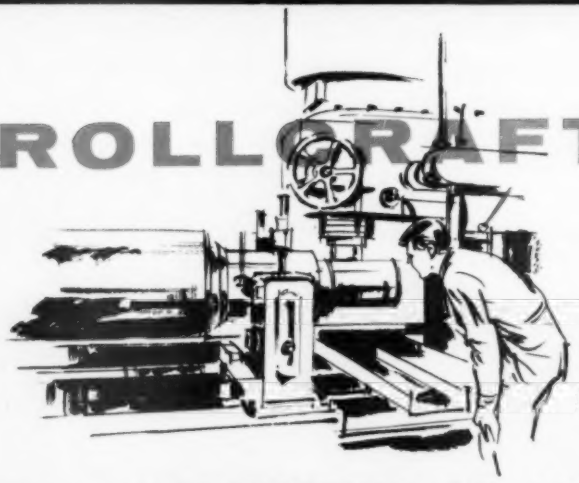

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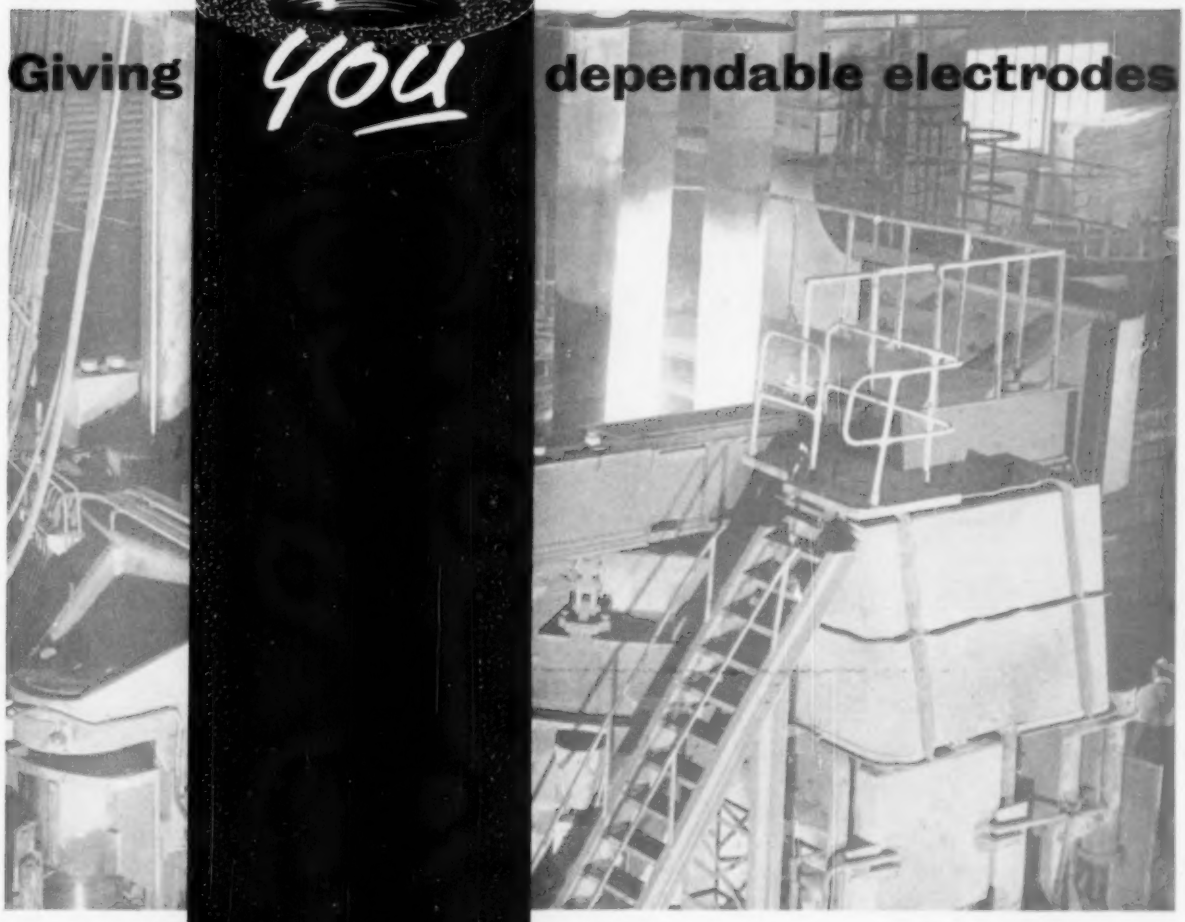

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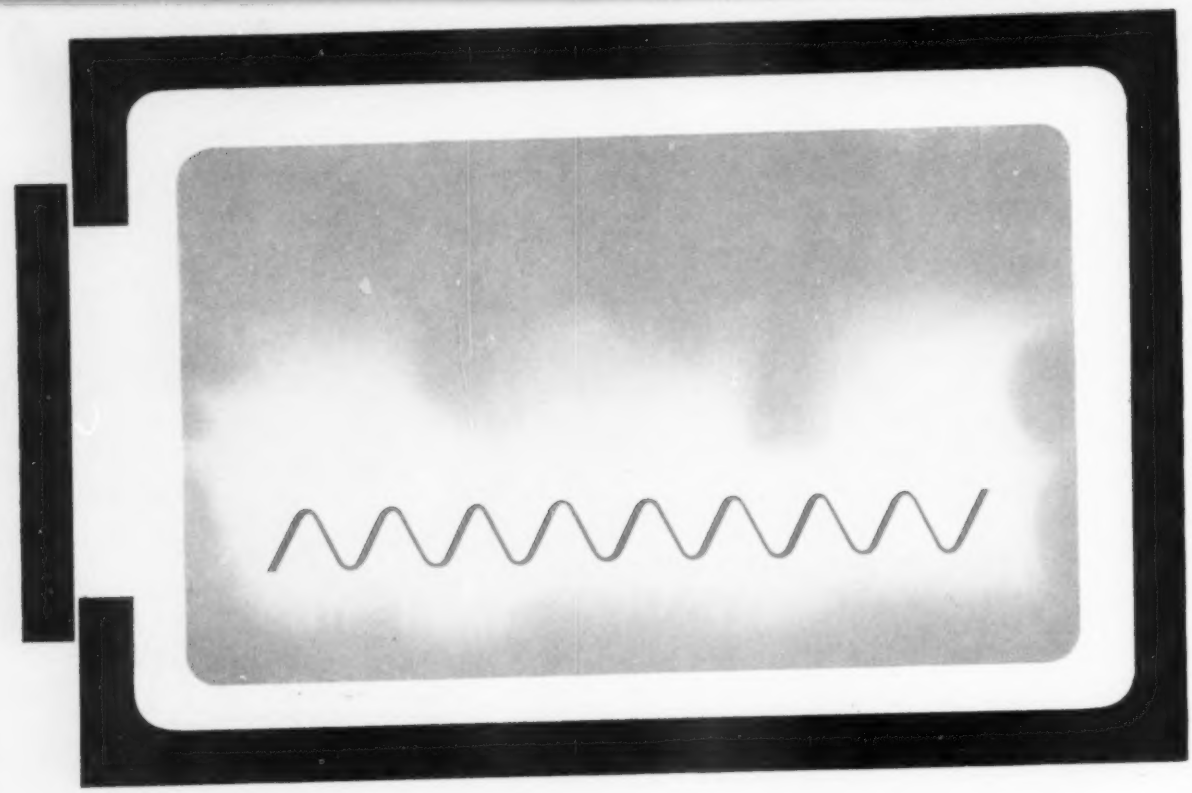

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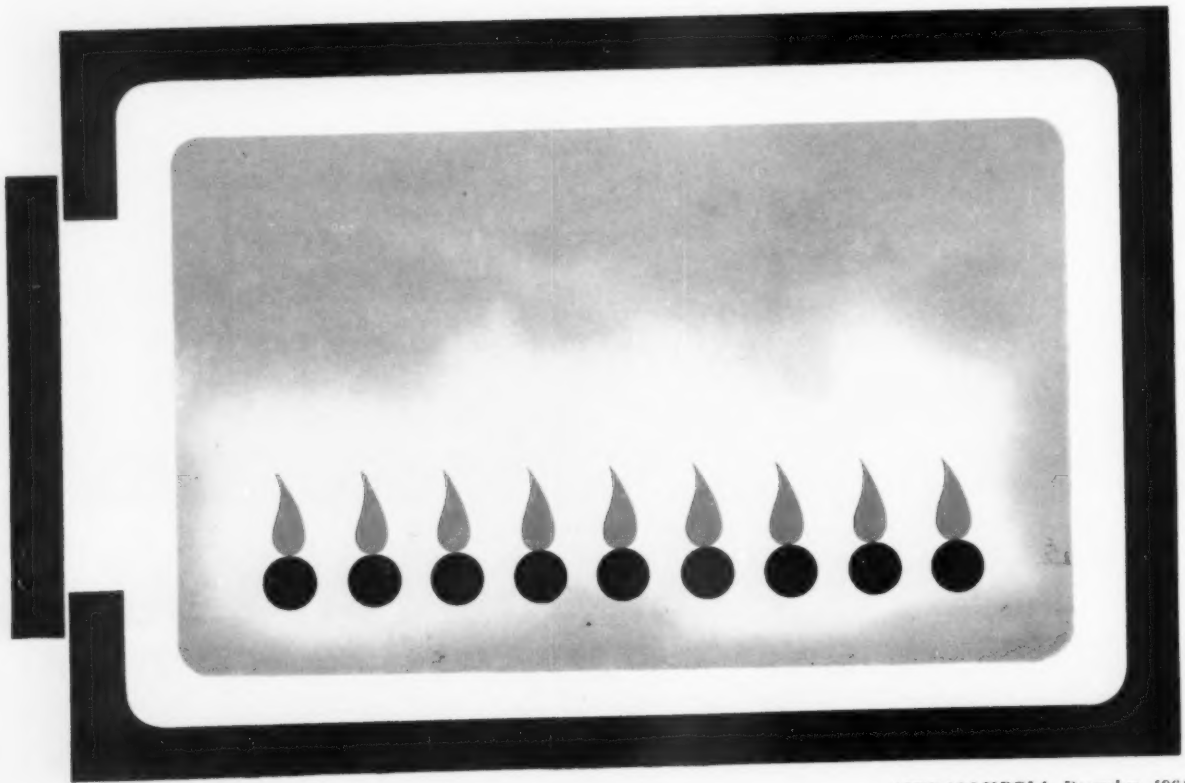

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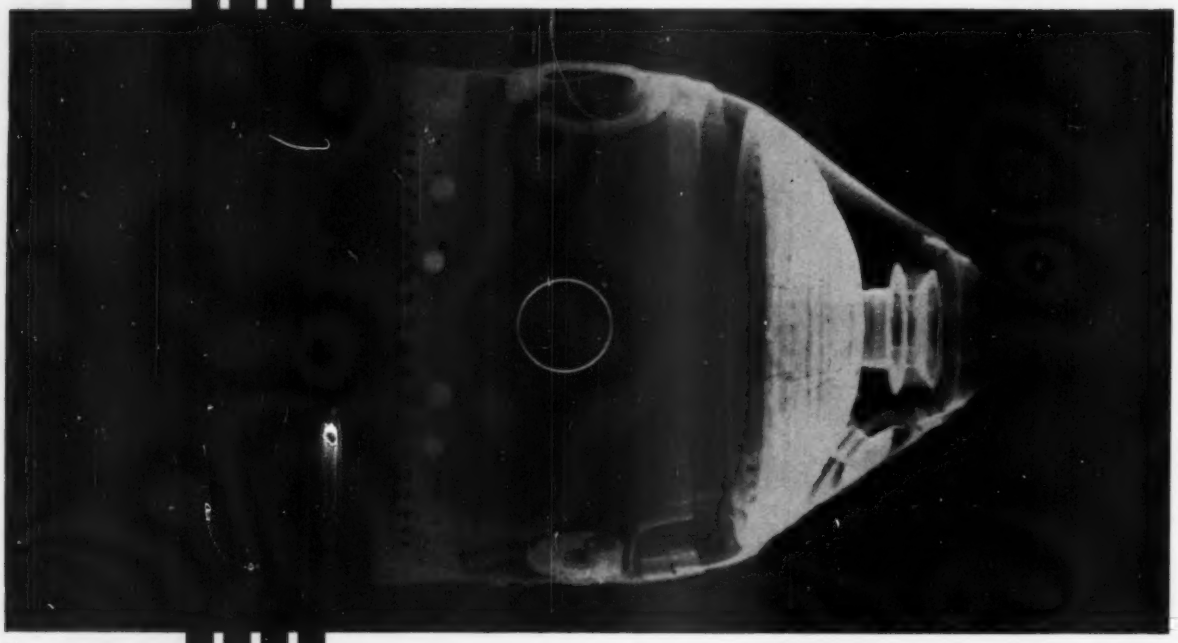

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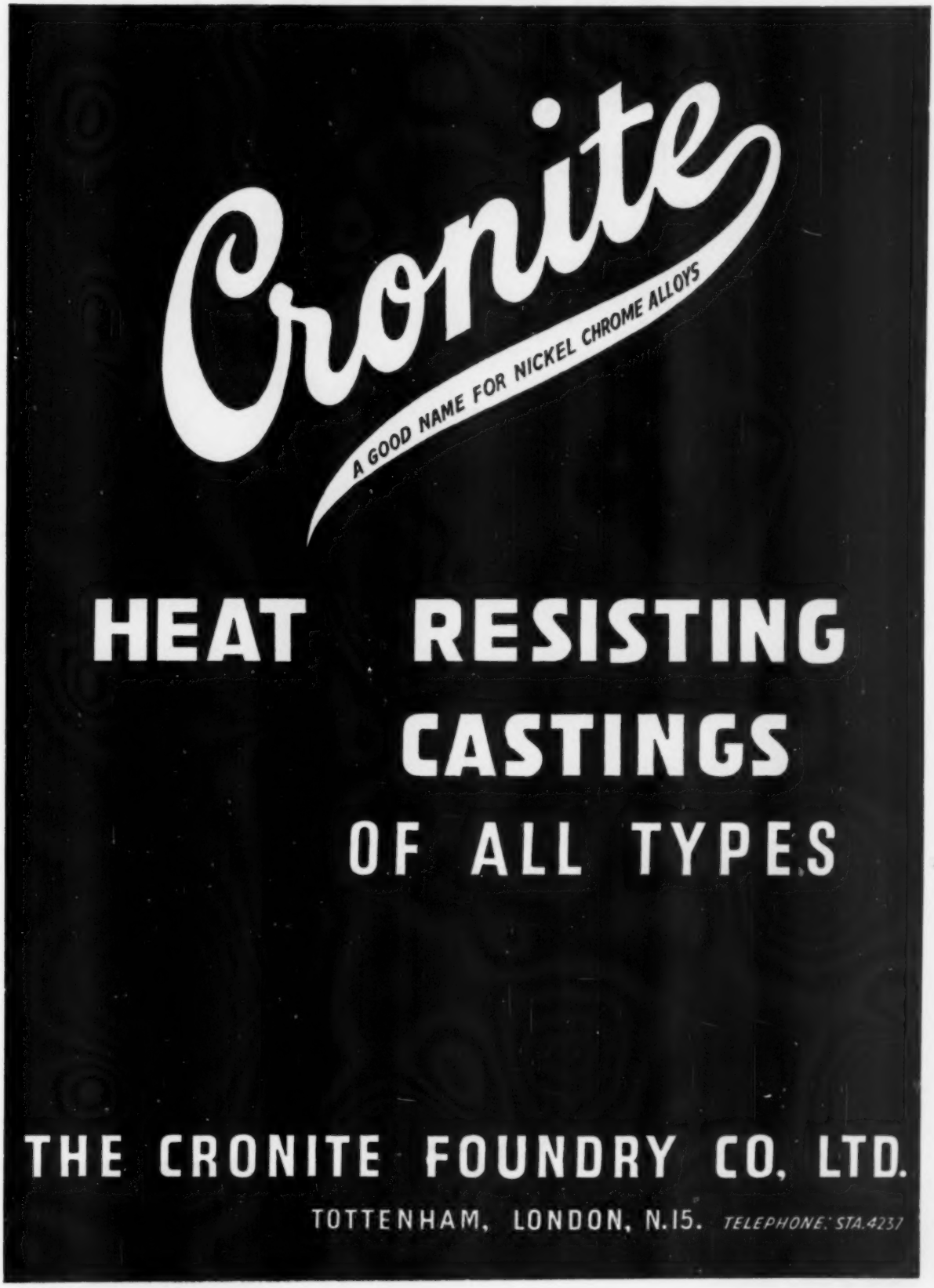
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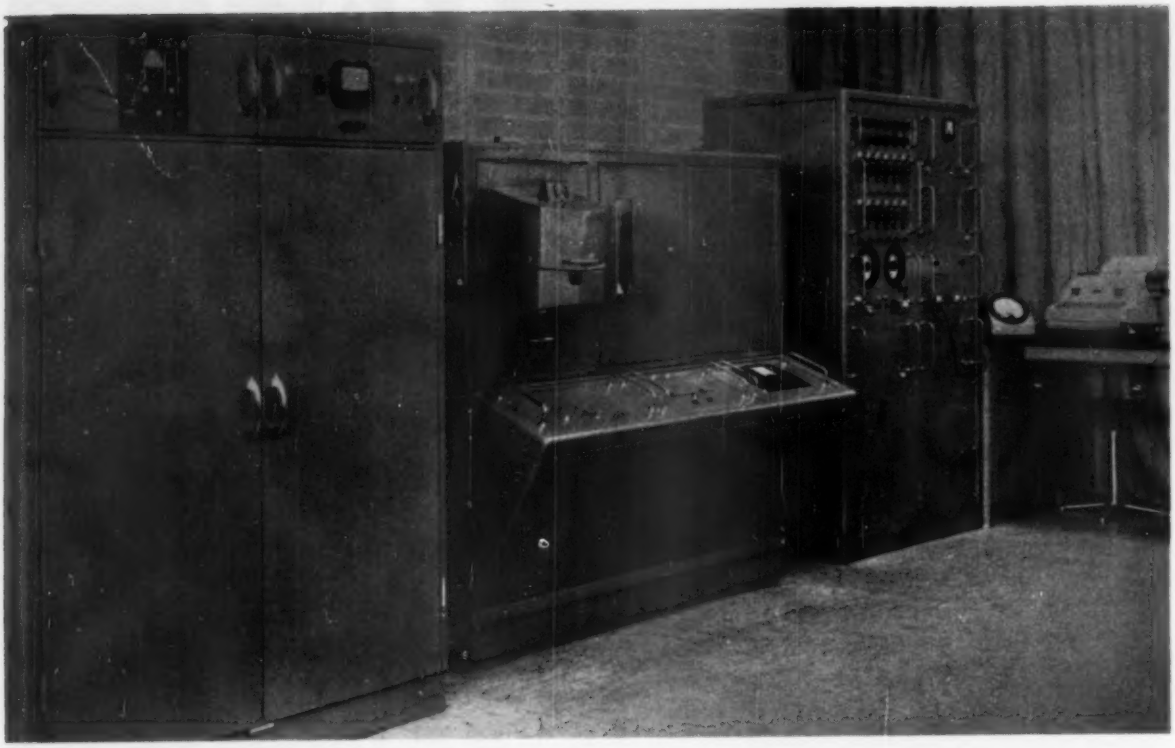

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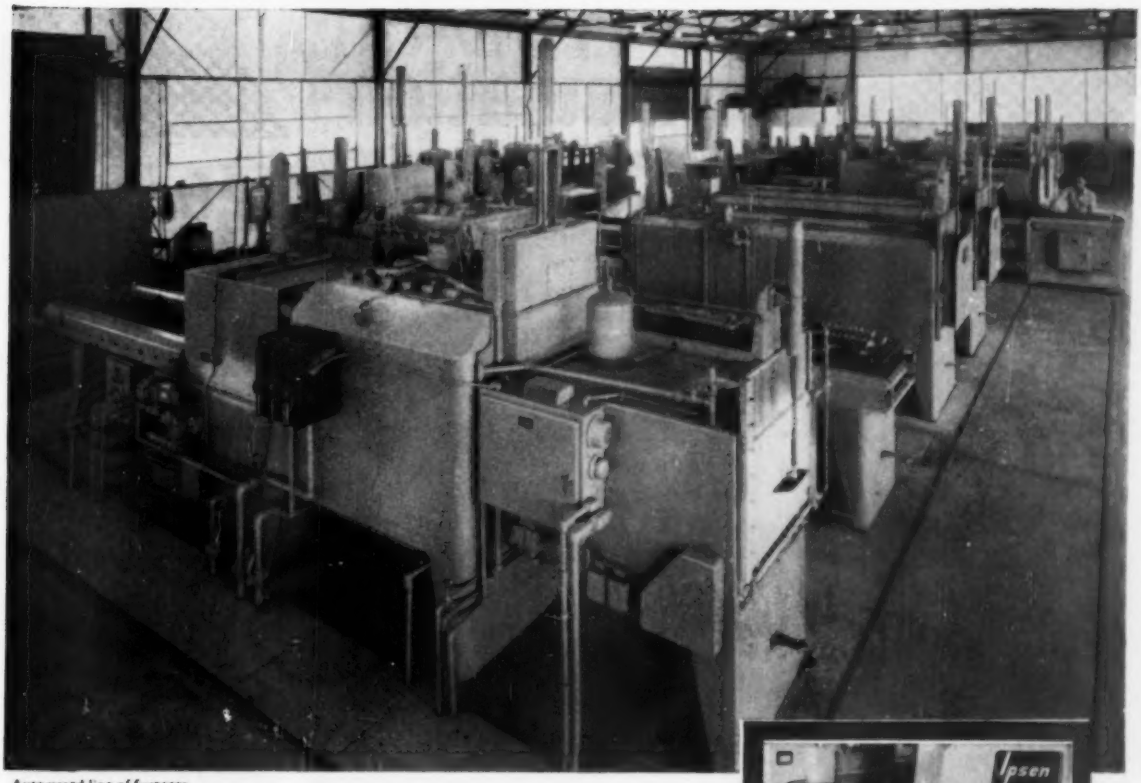

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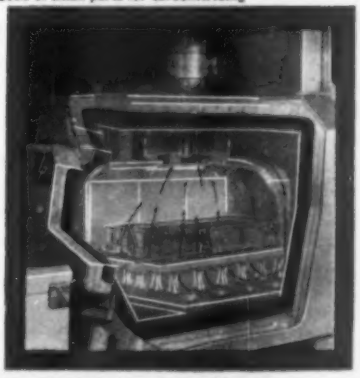

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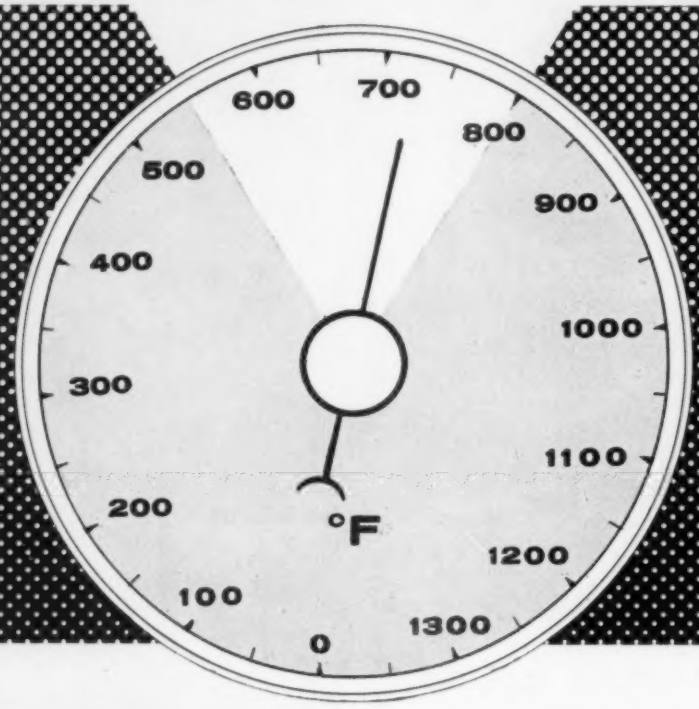

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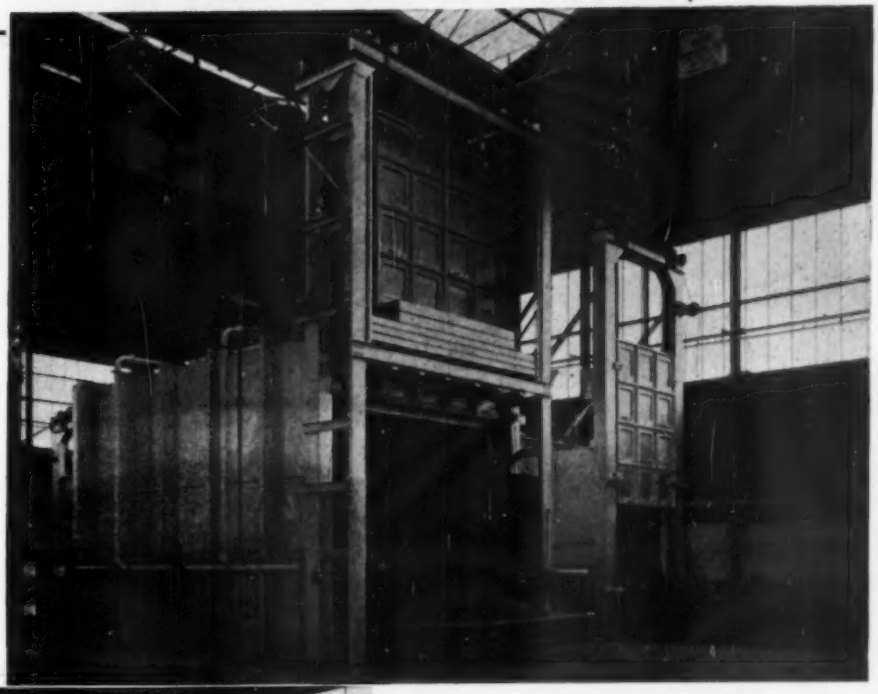

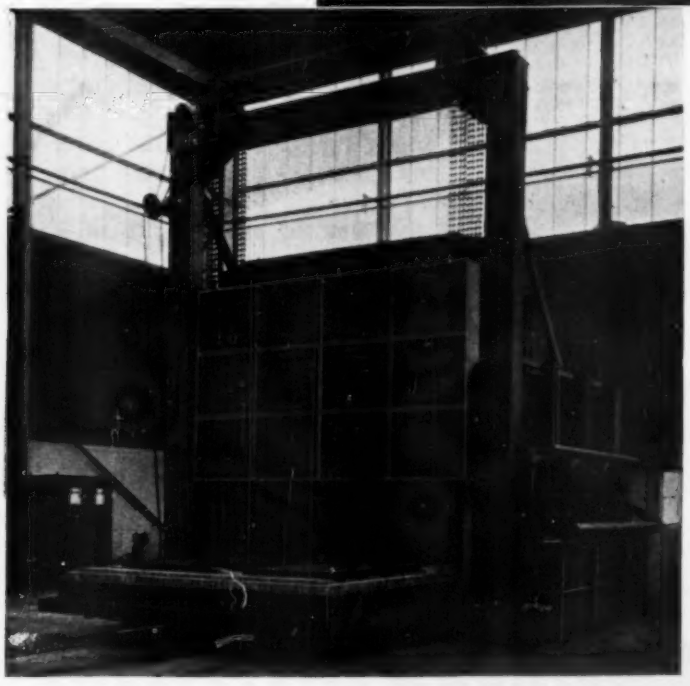

Two Gas Fired Bogie type Stress Relieving Furnaces

RIGHT *Door opening 8'0" wide x 10'2" high from flat top of bogie to the crown of the arch with a length from door face to back wall of 42'8". Maximum bogie loading 70 tons. Maximum burner capacity 16,500 cu.ft./hr.*

LEFT *Door opening 14'0" wide x 14'6" high, from flat top of bogie to the crown of the arch, with a length from door face to back wall of 24'4". Maximum bogie loading 25 tons. Maximum burner capacity 10,500 cu.ft./hr.*

Gas Fired Recuperative Bogie type Plate Heating Furnace. Door opening 12'6" wide x 6'1" high from flat top of bogie to crown (to spring 4'0") with a length from door face to back wall of 13'0". Maximum bogie loading—15 tons Maximum burner capacity—10,000 cu.ft./hr.

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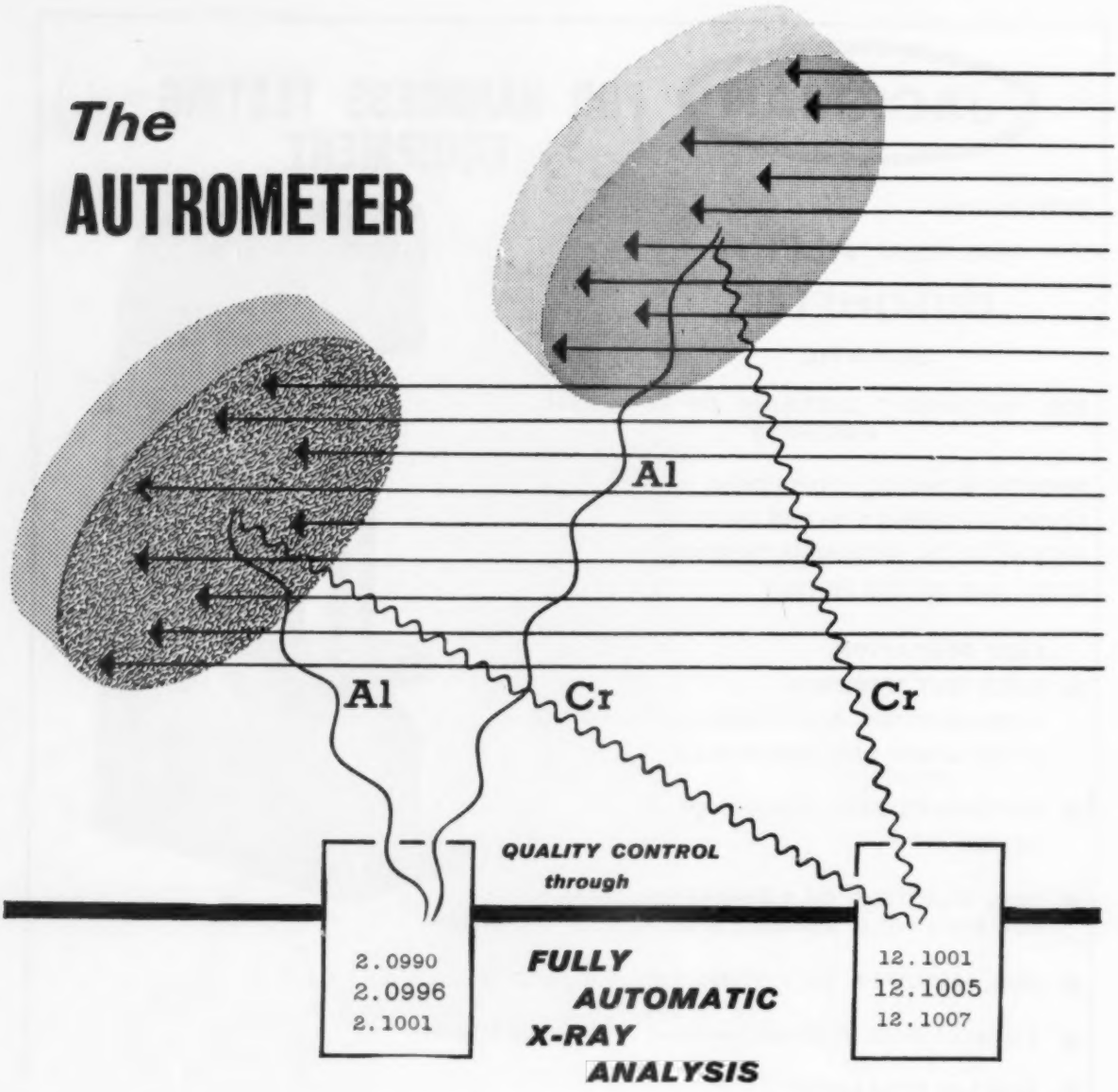

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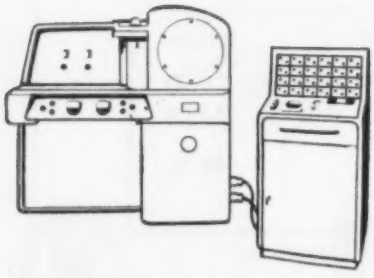

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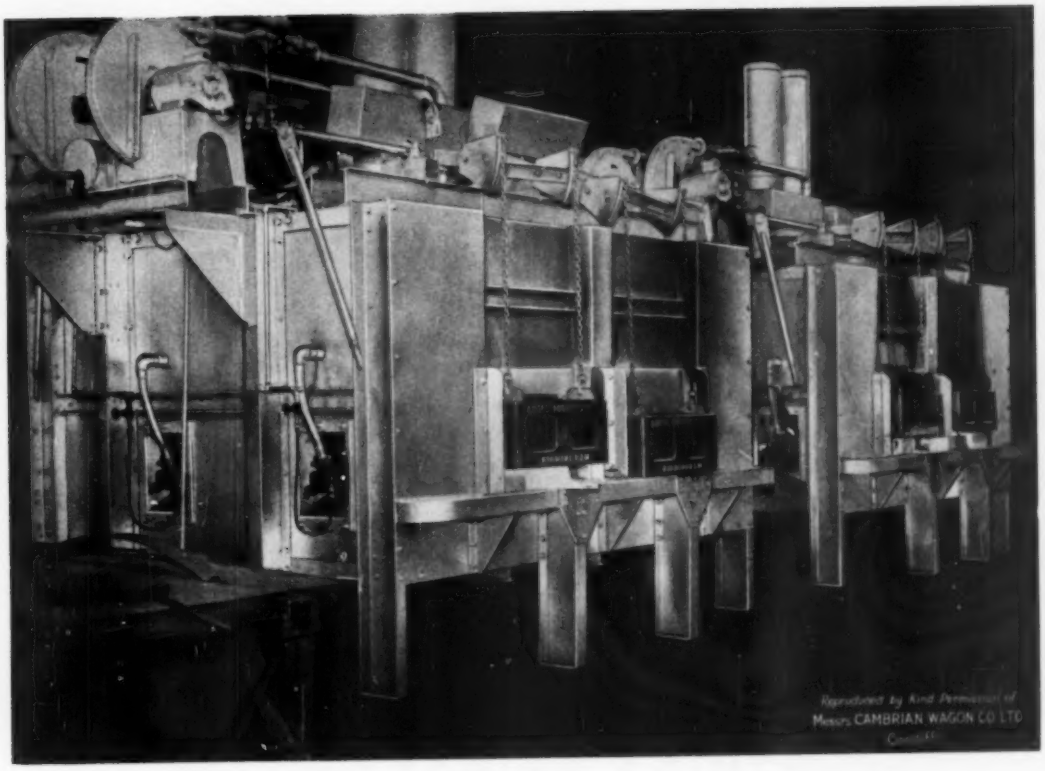

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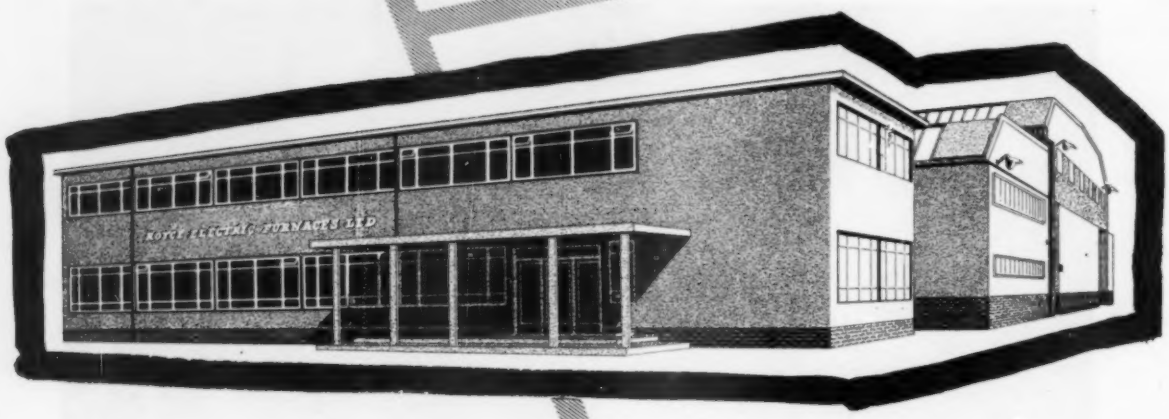

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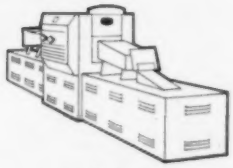

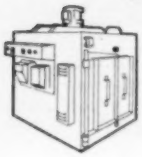

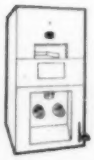

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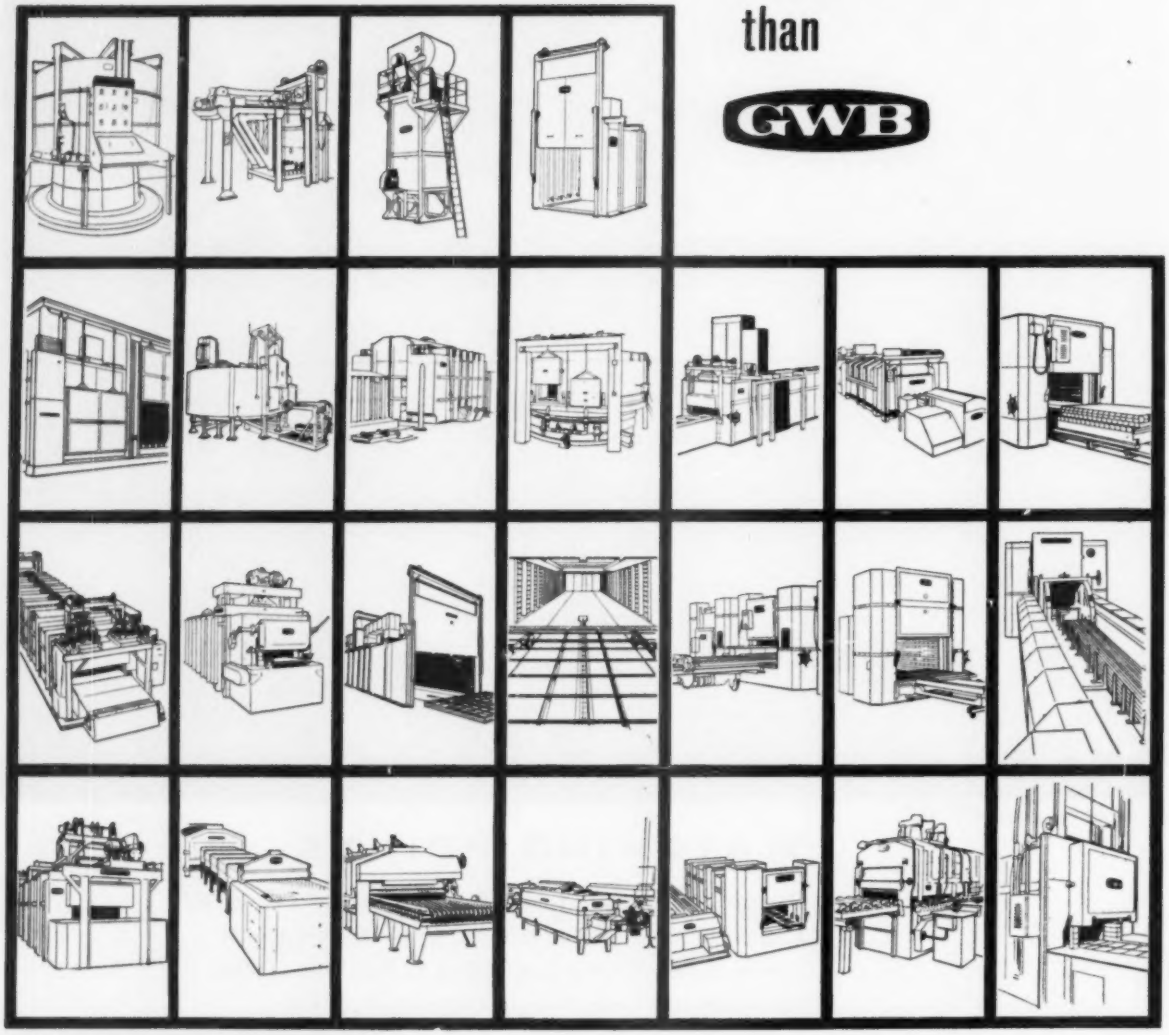

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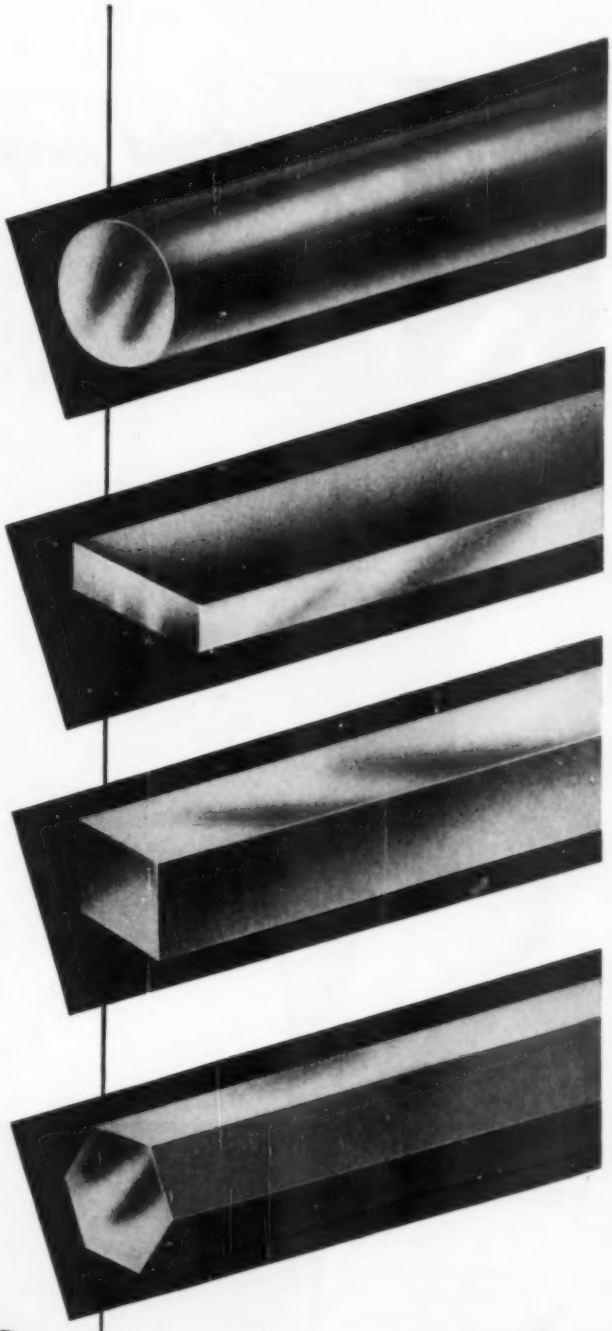

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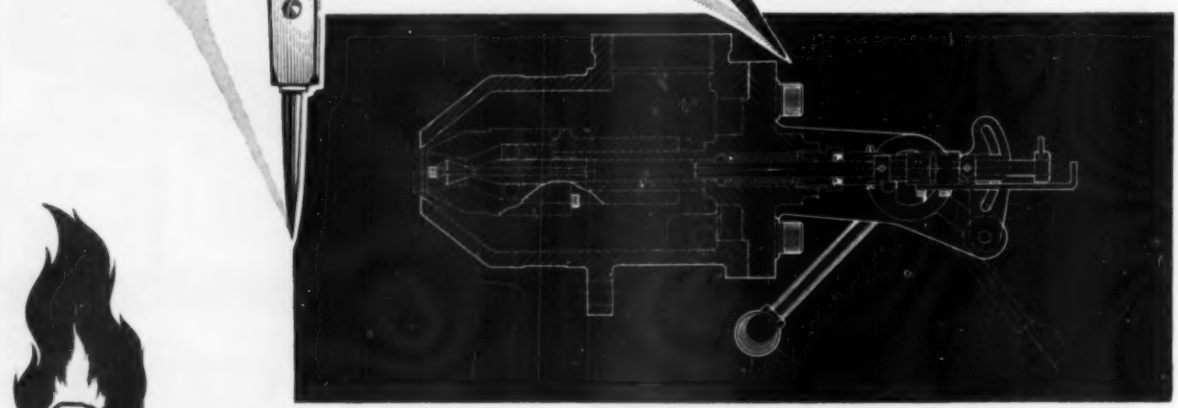

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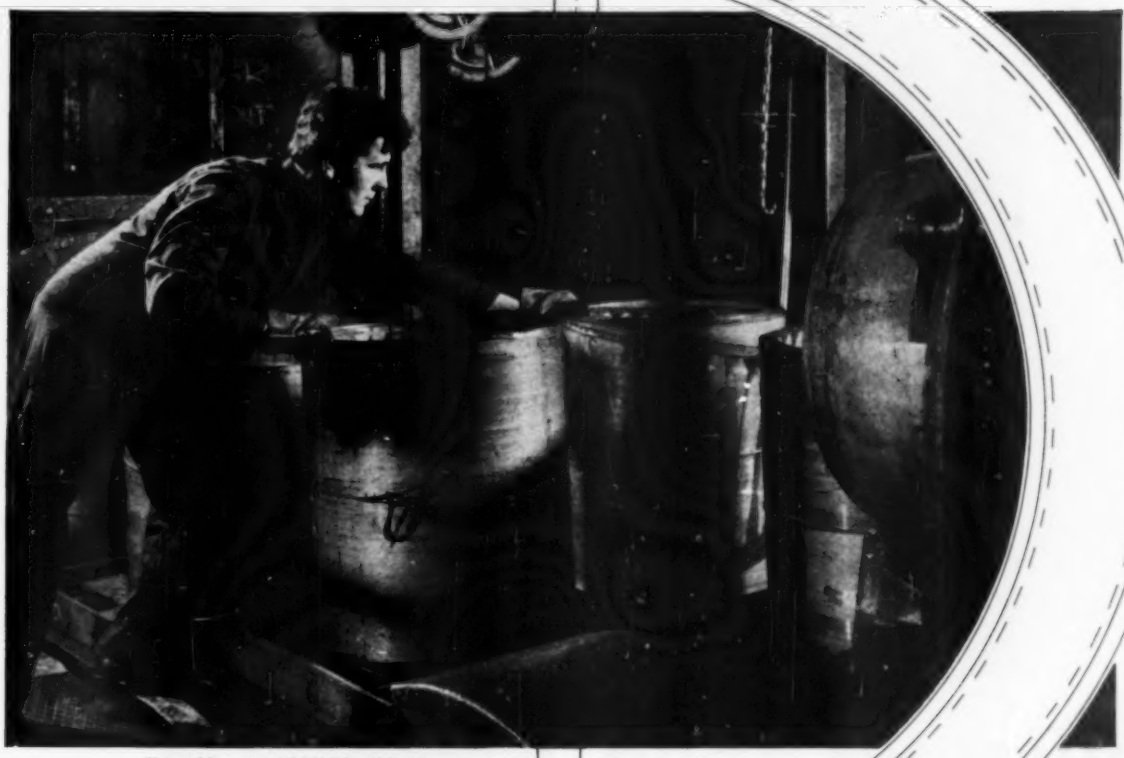

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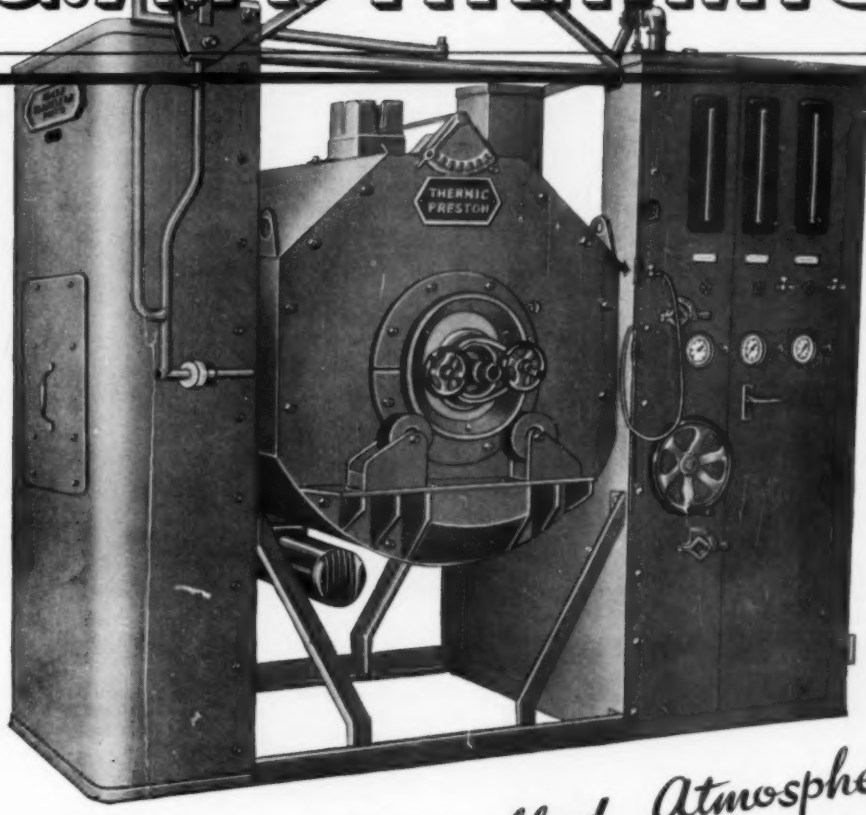

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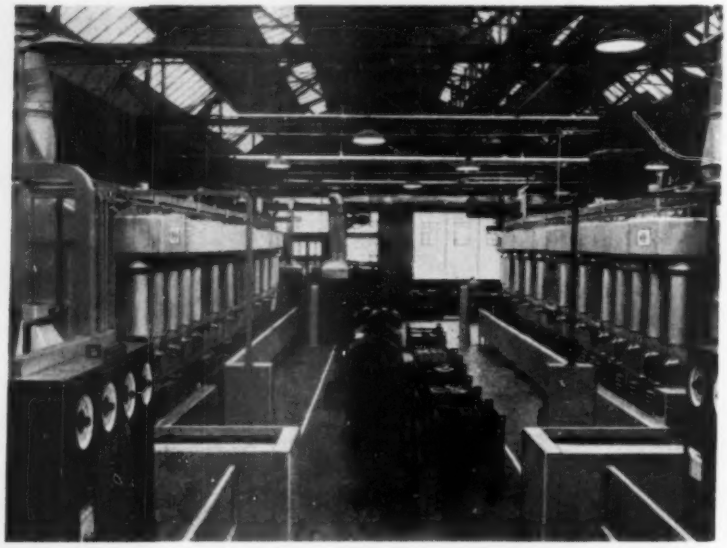

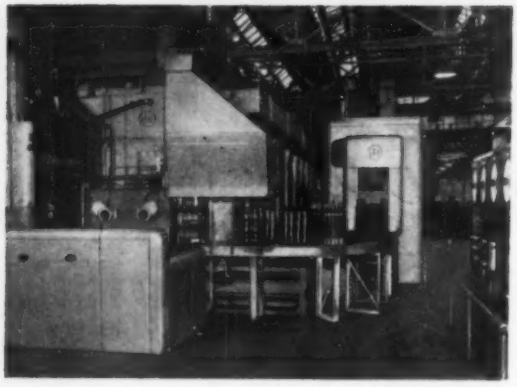

Illustration above : Loading and Control Bay for two Towns Gas Fired Pusher Continuous Gas Carburising Furnaces, 30 tray, two track for Crown Wheels, individually quenched.

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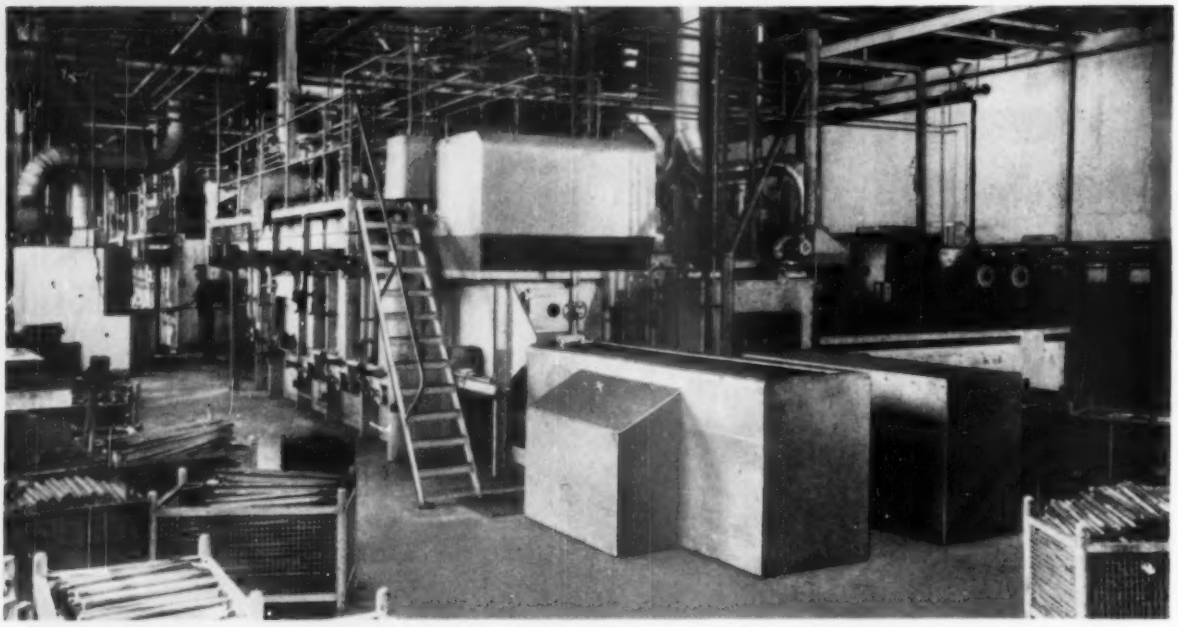

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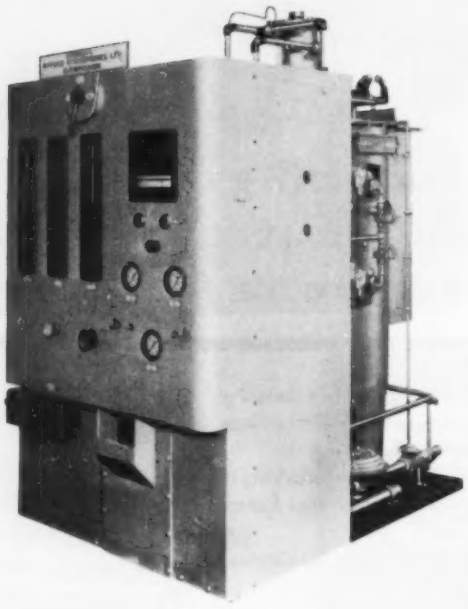

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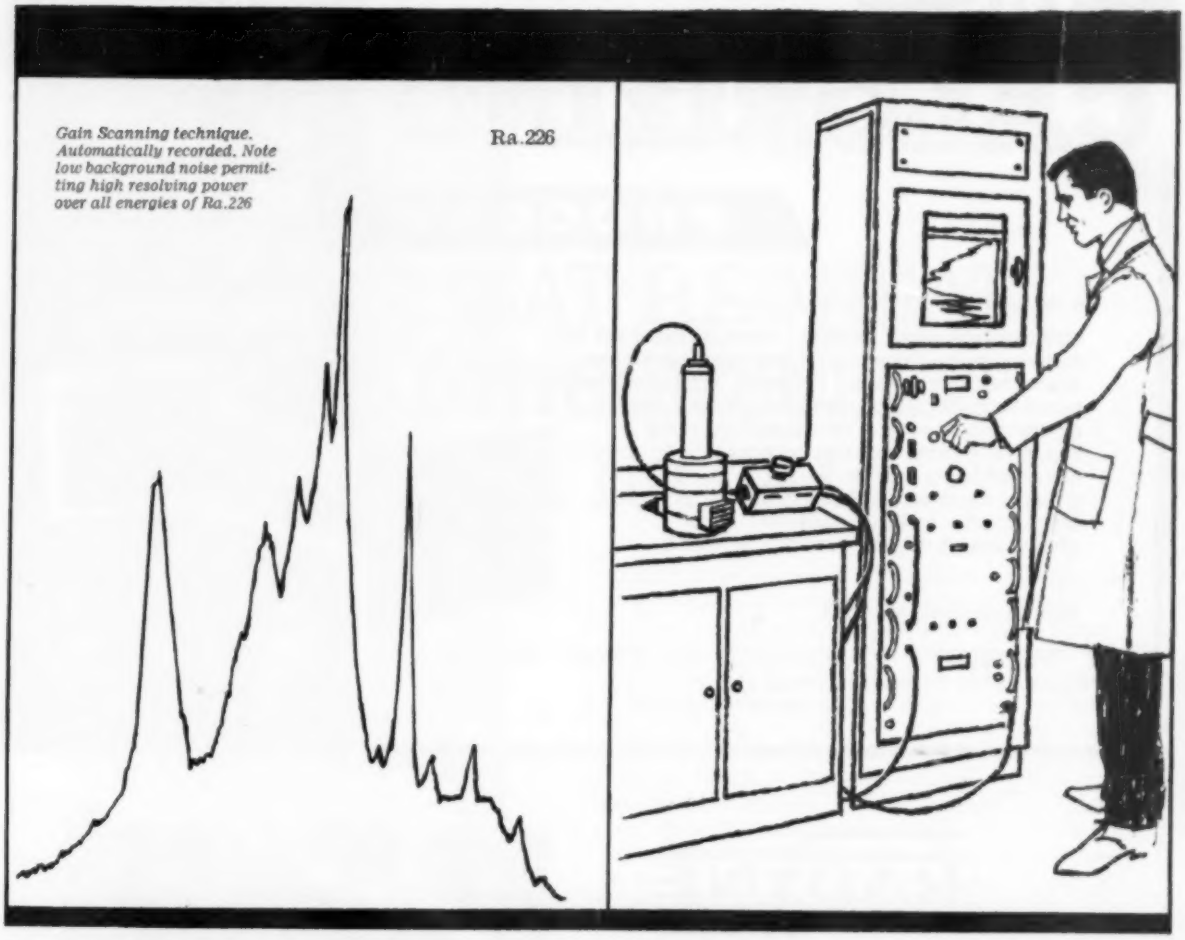
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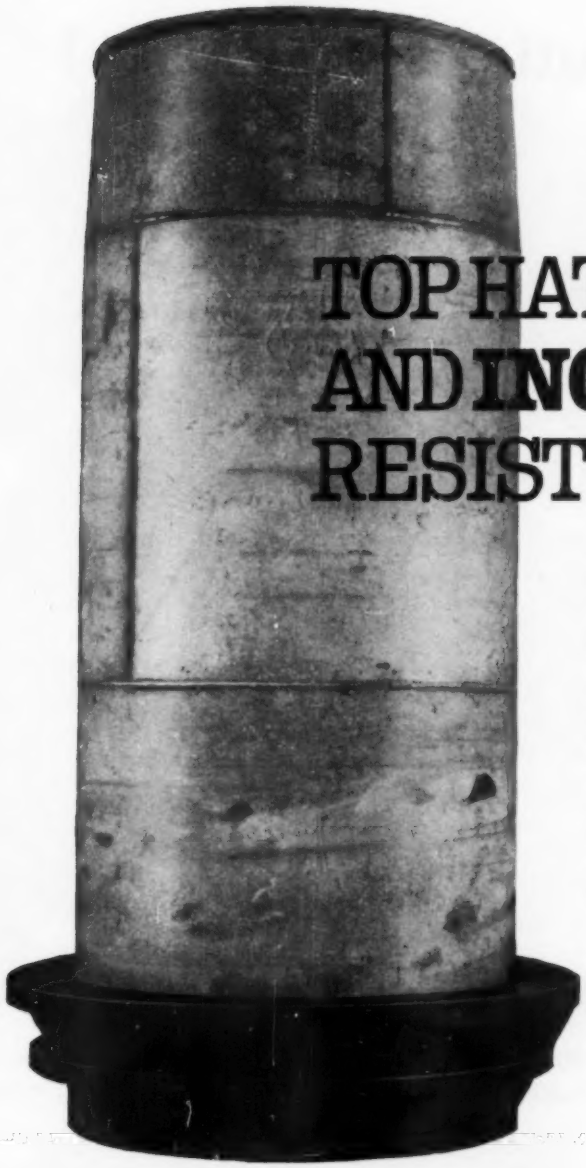

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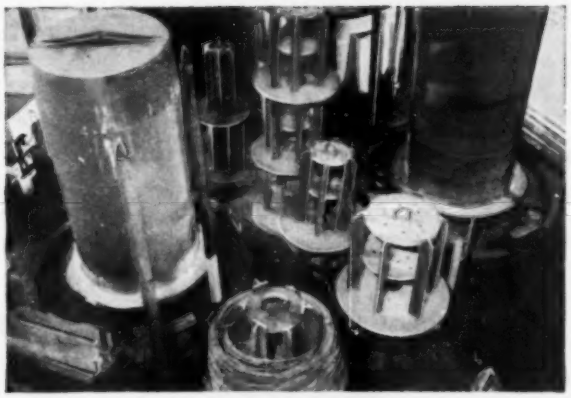
(Above) A top-hat annealing furnace retort and, (below) Efco bell-type furnaces with an uncovered charge of wire coil. The excellent resistance to oxidation and good high-temperature strength of INCONEL permit fabrication of thinner retort walls, allowing more rapid heating of the furnace charge with little absorption of heat by the retort itself. Use of INCONEL also means much longer retort life! *TRADE MARK



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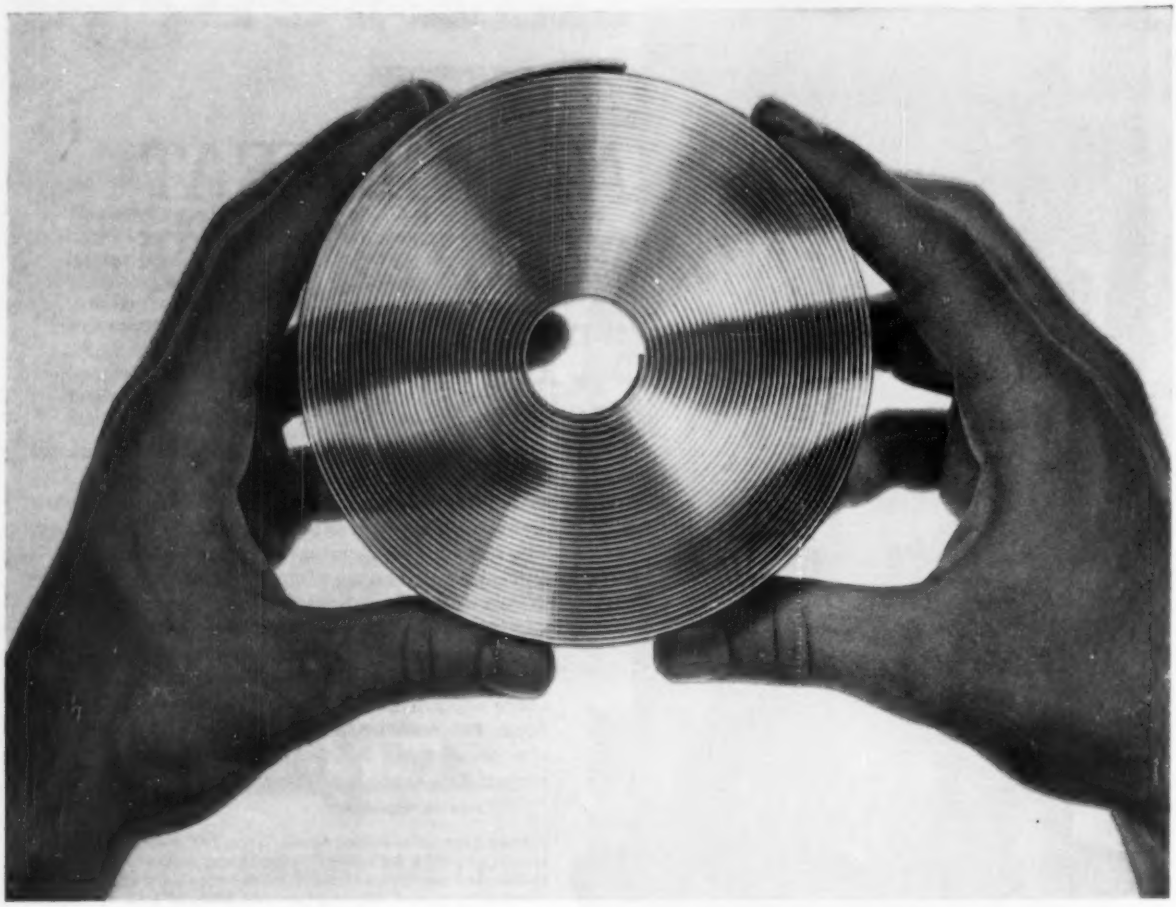

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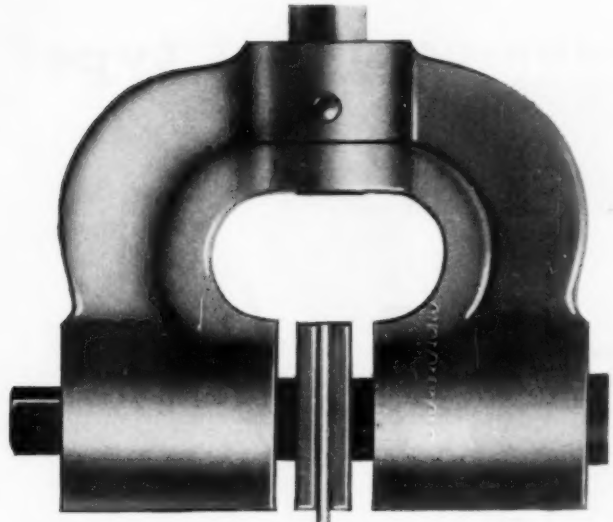

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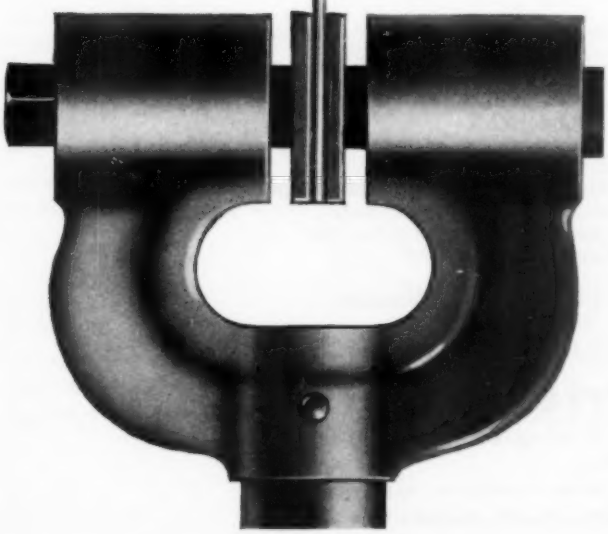

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METALLURGIA

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INCORPORATING THE METALLURGICAL ENGINEER

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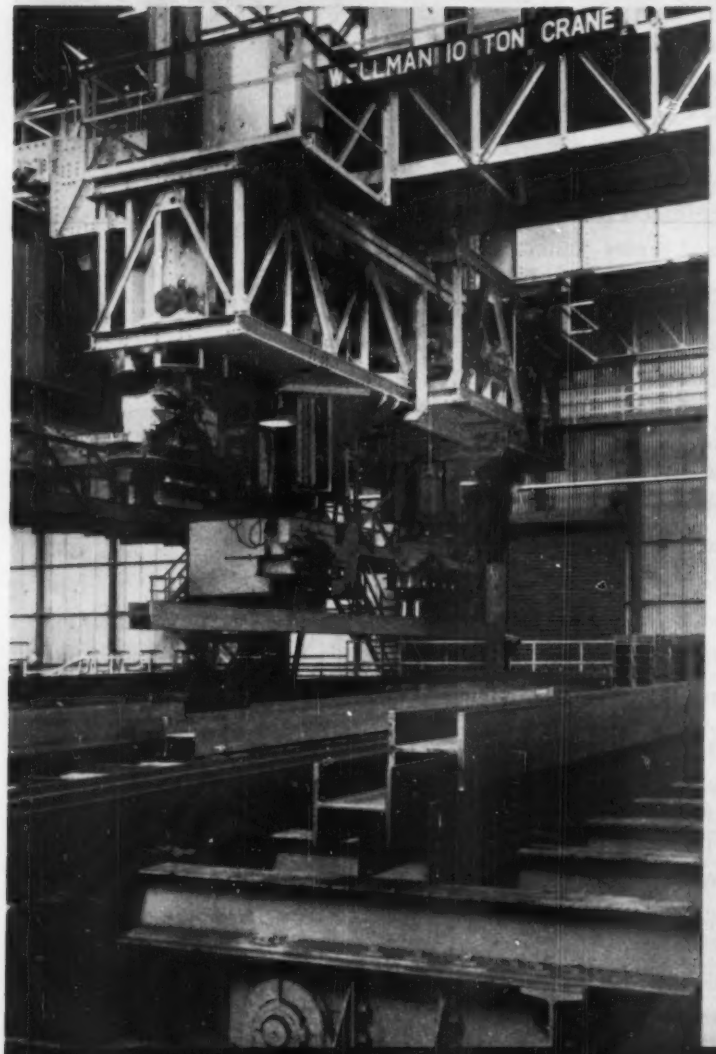

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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

DECEMBER, 1961 Vol. LXIV. No. 386

Steel and Europe

At a meeting organised by the Iron and Steel Institute and held at Church House, Westminster on 29th November, Mr. C. R. Wheeler, C.B.E., president of the British Iron and Steel Federation, speaking on the subject of the British Steel Industry and the Common Market, said: "The great weight of opinion in the British iron and steel industry welcomes the Government's decision to apply for full membership of the European Communities and hopes that the negotiations now under way will soon be brought to a fruitful conclusion."

We take this opportunity of extending to Readers our Cordial Greetings for the Festive Season and Good Wishes for the Coming Year.

He commented that on the general question of trade, taking the field as a whole, and bearing in mind that the Community market is a sophisticated one well suited to our highly-developed industrial pattern, he had no doubt whatever that the British steel-using industries stood to gain from bigger exports to Europe.

"The Industry hopes that entry into Europe may eventually bring still further gains through its revitalising effect on the economy as a whole . . . Entry into Europe . . . will generate new competitive forces which will give the whole economy 'a good shaking up'; and in so doing, it may break enough log-jams to release the full vigour, enterprise and determination which can be found throughout British industry."

Mr. Wheeler emphasised, however, that whatever the wider change, the essential thing now is to increase the steel industry's capacity to sell steel—both by improving the cost efficiency of our plants in every way possible, and by improving our sales machinery in all its aspects. The more successful we are in that aim, the more able we shall be to face whatever competition we may have to meet, whether it be from other materials in the home market, from our European friends in a widened Community or from American, Japanese, Russian or any other steel producers in the world market.

On the specific question of the *form* of membership he said: "The Federation has formally expressed to the Government its view that, if Britain were to join the European Economic Community, the Industry would favour full membership of the E.C.S.C. to any other arrangement, so far as E.C.S.C. products are concerned . . . The Industry hopes that these E.C.S.C. negotiations will be brought to an early and successful conclusion and that the British steel industry will be able to take up full membership of the E.C.S.C. without undue delay . . .

"Even though the Industry's support for full membership of E.C.S.C. implies a readiness to accept the main E.C.S.C. arrangements in their existing form, it will, of course, be necessary to seek some purely transitional arrangements to ease the unification of these two great markets—one of 75 million tons capacity and one of 25 million tons capacity—with their different traditional arrangements and practices. This will be especially the case if, as unfortunately appears likely, unification may actually take place in a period of considerable commercial difficulty. But any transitional arrangements of this sort should, the Industry accept, be limited both in scope and in time."

Mr. Wheeler then considered some of the detailed questions raised by entry into the E.C.S.C. "The British iron and steel industry, as a unit with real interests of its own, will not disappear overnight on entry to the E.C.S.C., any more than the German or French steel industries have disappeared. Indeed, the very fact of being inside a wider grouping increases, to some extent, the need for machinery through which to formulate and to express national viewpoints. Certainly the Steel Federations of the six present-day Community members have taken on new and important functions since the opening of the Common Market; and our Federation may possibly follow the same course . . . This does not imply that the central arrangements of the Industry will all continue unchanged in their present form after entry into the E.C.S.C. The position of the Industry Fund generally and of the central importing arrangements in particular will need to be carefully considered . . ."

He had been somewhat disturbed to learn that normally well informed Continental observers have failed to realise how far the Industry has gone in the last few years in demolishing those aspects of the Fund's operations which were more appropriate to the planned regimes of the 'forties and early 'fifties than to the more competitive conditions of the later 'fifties and 'sixties. For example, it is now an established principle that imported ore must be resold at prices sufficient to cover its full import cost over a reasonably short period of time; no form of assistance is now being paid out of the Fund to enable certain necessary but high cost transactions to proceed within the tight limits of maximum price control; and there is at present no central loss-bearing on pig iron, scrap, ingots or semis imported for resale at home prices. The whole scale and importance of Industry Fund operations have been much reduced; and as a measure of that the ingot levy is now less than 2% of the rate ruling in the early 'fifties . . .

"Any major revision of the British scrap arrangements would almost certainly involve some increase in the Industry's total cost level and, to that extent, the issue is one which must still be approached with considerable caution . . . we should nevertheless bear in mind that the world scrap market as a whole is in a situation of rapid change and that the Industry should not therefore be too rigid in its approach to this matter . . .

". . . the Industry is of the opinion that Britain's entry into E.C.S.C. would require an urgent reassessment of national fuel policy. As you will all be aware, the sizeable

cost advantages which the British steel industry once enjoyed *vis-à-vis* Continental producers have progressively been lost in recent years. In part, this has reflected an unhappy trend of events in Britain's coal industry itself: for example, since the opening of the E.C.S.C., the pithead price of the British coking coal bought by the Industry has gone up nearly 60%, whereas the prices of Community coking coal have not risen by more than 16% in any basin and have actually fallen in some areas, such as Northern France and Holland. In part also, it has reflected differences in national coal import policies, as a result of which the Community steel-works which are being developed on coastal sites are able to enjoy large imports of cheap American coal on a regular basis, whereas British coastal plants are forced to rely on home supplies which are, in one case which comes to mind, some 30s. a ton dearer. In this matter, I must make the Industry's position quite clear. British steel producers cannot be expected to compete in a freer Community market with this handicap of excessive fuel costs still rivetted upon them. If the Government decides to place British steelmakers in more competitive conditions *vis-à-vis* their end products, then the Government must equally ensure more competitive conditions *vis-à-vis* fuel supplies. There must be genuine freedom of trade in coal as well as in steel within the Community area; and as regards imports from third countries, the Government should extend to coal the reasonable degree of import freedom recently granted in respect of liquid methane . . .

"*Prices* . . . there can be no doubt that radical changes face the British steel industry. We must expect at some reasonably early date to have to abandon a system of uniform zonal delivered prices which has, in its essential features, stood for more than a quarter-century; and in its place, we must expect to introduce an E.C.S.C. system, with reliance on published basing point prices, and with regulated price alignment as a further important innovation. In other words, we shall all—consumers as well as producers—have to learn some complicated new tricks; and we shall have to learn them quickly. What all this will involve in practice, and how best we can all learn those new tricks as painlessly as possible is a matter to which the Federation is now devoting close study . . .

"The E.C.S.C. pricing system requires the charging and publication of non-discriminatory transport rates. Here we are in the hands of the British Transport Commission and the Government . . . This is a matter of great importance for future rate-fixing policy in the British transport system as a whole . . .

"A particular problem for the steel industry arises out of the structure of British taxation in the light of the E.C.S.C.'s present pricing rules. When a country imposes a relatively high proportion of its tax burden in the form of turnover or sales taxes, its producers gain a competitive advantage when they sell to other Community countries. In Britain none of the tax burden falling on the steel producers arises in the form of turnover or sales taxes, and so our position in the Community would seem likely to be even worse in this respect that that of any other country. This is a matter requiring urgent study."

Mr. Wheeler further commented: "It has already been widely suggested in the Press that there seems to be an important clash of competences between the Iron and Steel Board and the E.C.S.C. High Authority. These are, however, complicated and difficult legal and constitutional matters to which the Government will have to give most careful consideration."

Meeting Diary

January 3rd

Institute of Welding, Manchester and District Branch. "Fundamental Metallurgical Considerations and Effects of Gases in Welding," by W. D. BIGGS. 36 George St., Manchester. 7.15 p.m.

January 4th

Institute of Metals, London Local Section. "New Methods of Powder Generation," by J. M. SPRING. 17 Belgrave Square, London, S.W.1. 6.30 p.m.

January 5th

Institute of Physics and the Physical Society. Symposium on "Some Aspects of Vacuum Science and Technology" Imperial College, London. Registration necessary.

January 8th

Institute of British Foundrymen, Sheffield and District Branch. Discussion on "Foundry Problems" led by A. TIPPER, A. D. MORGAN, J. M. GREENHILL, and R. V. RILEY (Papers presented at the last Annual Conference.) Grand Hotel, Sheffield. 7 p.m.

January 8th–12th

Institution of Mechanical Engineers. International Heat Transfer Conference. (A repeat of the conference held in Boulder, Colorado, from 28th August to 1st September, 1961.) Lecture Hall, Central Hall, Westminster. Registration necessary.

January 9th

Institute of Metals, Oxford Local Section. "Selling a Metal—The Technical Aspects of Developing New Outlets," by M. BRIDGEWATER. Cadena Cafe, Cornmarket Street, Oxford. 7.15 p.m.

January 11th

Institute of Metals, Birmingham Local Section. "Some New Bearing Metals," by P. G. FORRESTER. College of Advanced Technology, Gosta Green, Birmingham. 6.30 p.m.

January 12th

West of Scotland Iron and Steel Institute. "Research on Research," by J. H. CHESTERS. (Joint meeting with **Refractories Association.**) Institution of Engineers and Shipbuilders in Scotland. 39, Elmbank Crescent, Glasgow, C.2. 7 p.m.

January 15th–19th

Institute of Physics and the Physical Society. 46th Exhibition of Scientific Instruments and Apparatus. Royal Horticultural Society's Halls, London. Admission by ticket only, available from the Secretary.

January 16th

Society of Chemical Industry, Corrosion Group (Midlands Branch). "Corrosion Problems in Civil Engineering" by L. H. EVERETT. Engineering Centre, Stephenson Place, Birmingham. 7 p.m.

Institute of Metals, South Wales Local Section. (Joint meeting with the **Industrial Museum of South Wales, Ltd.**) The Royal Institution, Swansea. 7 p.m.

Institute of Petroleum, Northern Branch. "Oil and Steel," by J. A. ROBERTSON. Engineers' Club, Albert Square, Manchester, 2. 6.30 p.m.

Operational Research Society. "A Quasi-servomechanistic Interpretation of Absence Behaviour in a Steelworks," by S. LANER. College of Science and Technology, Manchester. 7 p.m.

North East Metallurgical Society. "Metals in the Home," by J. H. GITTUS. Cleveland Scientific and Technical Institution, Corporation Road, Middlesborough. 7.30 p.m.

(continued on page 302

Effect of Silicon on Tensile Properties of D.T.D. 5008 Test Bars

By J. E. Stolarczyk, A.C.T.(Batt.), A.I.M.

Senior Metallurgist, J. Stone and Company (Charlton) Limited

A short investigation on the effects of silicon on the tensile properties of laboratory and production test bars in D.T.D. 5008 alloy is described and a brief review of other available information is included. A useful alternative to the standard artificial ageing treatment is also suggested.

THE heat treatment of castings is always inconvenient, but with very large castings it may become almost impossible. Such castings are produced comparatively infrequently and, therefore, most foundries do not have the required heat treatment equipment or capacity to cope with this type of problem. Furthermore, in some cases there is the likelihood of the introduction of stresses into the casting during quenching after solution treatment, and this may occasionally lead to cracking or distortion on machining. The high strength and proof stress and comparatively good ductility that can be obtained in D.T.D. 5008 castings, after three weeks natural ageing, makes the alloy particularly attractive for applications where heat treatment is a problem. In addition, the alloy possesses good machinability and resistance to corrosion and is dimensionally stable. As a result, the popularity of this alloy is increasing.

It is generally accepted, however, that in common with some other aluminium alloys, the margin between the specified properties (14 tons/sq. in. and 4% elongation) and those generally obtained under production conditions is not large. Therefore, to meet consistently the requirements of the many inspection authorities, a strict control of metal quality is necessary. For these reasons it was decided at the laboratories of J. Stone and Co. (Charlton), Ltd., to investigate, among other aspects, the effects of silicon on the properties of laboratory and production test bars. The bars investigated contained up to 1% silicon and were tested after natural ageing for up to six months. The results of bars tropicalised for three days at 70° C. are also included.

Previous Work

The effects of up to 0·45% silicon on the properties of Al-Zn-Mg alloys were studied by Eastwood and Kempf[2] and by Sicha and Hunsicker[3]; their results are summarised in Fig. 1. The alloys investigated contained 6·5% zinc, 0·3–0·7% magnesium, 0·35–0·5% copper, 0·10–0·15% iron and 0·15% titanium. Ageing treatments of 4 hours at 100° C. or 30 days at 30° C. were used.

Although both the composition and the heat treatments do not conform to those specified for the D.T.D. 5008 type of alloy*, the conclusions to be drawn from

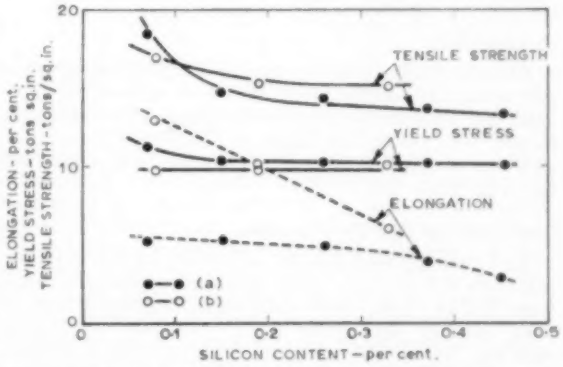


Fig. 1.—Effect of silicon content on the tensile properties of Al-Zn-Mg-Cu alloys, according to (a) Sicha and Hunsicker, and (b) Eastwood and Kempf.

their results are that silicon contents in excess of about 0·15% lower the properties (particularly the tensile strength) to values which give practically no margin of safety over specification requirements.

Comstock[1] has also found that 0·5% additions of silicon to this group of alloys have a detrimental effect on their properties.

In view of these findings it is rather surprising to find that most specifications allow up to 0·25–0·3% silicon*.

Experimental Methods

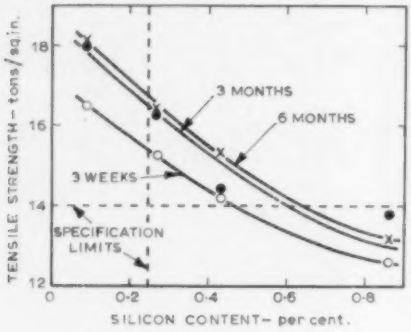
Materials and Melting

All alloys were prepared using commercial ingot material, conforming to specification D.T.D. 5008, to which additions of aluminium–20% silicon hardener were made to obtain the silicon levels required.

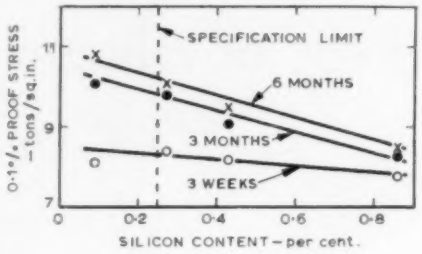
The laboratory melts were prepared in a lift-out, gas-fired crucible furnace. They were fluxed, grain-refined and degassed in the usual manner using proprietary materials. All test bar castings were poured at 720°–730° C. after the melts were checked for gas content using the reduced pressure test. The procedure for production melts was the same except that oil-fired tilter furnaces were used.

* See Appendix.

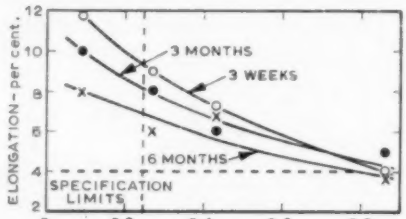
* See Appendix.



(a)



(b)



(c)

Fig. 2.—Effect of silicon on the mechanical properties of D.T.D. 5008 alloy after various ageing times : (a) tensile strength ; (b) 0·1% proof stress ; and (c) elongation.

Composition

Because the same batch of ingot material was used for all laboratory melts, only the first melt was fully analysed, silicon only being determined in the remaining melts. The results are listed in Table I. The silicon, zinc and magnesium contents of the production bars are listed in Table III.

Test Castings and Tensile Tests

Test castings used for the laboratory melts were the standard E-type bars, while those for production melts were D.T.D. bars. Both were made in green Mansfield sand moulds containing 5–6% moisture. 0·564 in. diameter British Standard test pieces were machined from the castings and their tensile strength, 0·1% proof stress, and elongation were determined. Each point on the graphs shown in Fig. 2 represents a mean of three determinations.

Ageing

Four laboratory melts with different silicon contents, as indicated in Table I, were produced. Each melt consisted of twelve bars. Three bars at each silicon content, giving a total of twelve bars, were aged at room temperature for three weeks and three and six months. The fourth batch of bars was tropicalised three days at 70° C. in an air circulation furnace.

All production bars were aged at room temperature for three weeks.

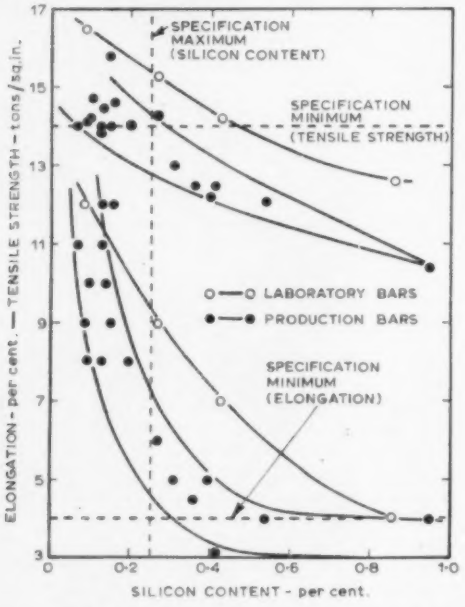


Fig. 3.—The influence of silicon content in D.T.D. 5008 alloy on the tensile properties of production and laboratory test bars after natural ageing for three weeks.

Results and Discussion

The results for all laboratory bars are listed in Table II and are illustrated in Fig. 2. Results for production bars are reported in Table III and Fig. 3 : Figs. 4 *a* and *b* show typical microstructures of bars containing 0·27 and 0·86% silicon, respectively.

Silicon Content

Fig. 2 indicates that silicon seriously reduces the

TABLE I.—COMPOSITION OF LABORATORY MELTS.

Element	Composition (%)			
	Melt No. 1	Melt No. 2	Melt No. 3	Melt No. 4
Copper	0·02	As for No. 1 (allow for the diluting effect of aluminium-silicon hardener additions)		
Zinc	5·50			
Aluminium	Balance			
Manganese	0·01			
Tin	0·01			
Iron	0·25			
Nickel	0·01			
Lead	0·01			
Magnesium	0·50			
Chromium	0·51			
Titanium	0·25			
Silicon	0·09	0·27	0·43	0·86

tensile properties of the alloy. Although at 0·25% silicon, which is the maximum allowed by the D.T.D. 5008 specification, all the laboratory test bars had properties in excess of requirements, the margins were not very large even after six months ageing. As regards 0·1% proof stress, the expected value of 10 tons/sq. in. was not reached, even after three months ageing. Production melts cannot be as strictly controlled as laboratory melts and, therefore, greater variations in the soundness of the bars is to be expected. In Fig. 3 the effect of silicon on the limits of tensile strength and ductility of production test bars after three weeks natural ageing is shown. The detrimental influence of silicon on the tensile strength is even more marked in this case, and it would seem advisable to keep the silicon content below 0·1% if the present specification requirements are to be met consistently under production conditions. However, this type of alloy is nominally prepared from the 99·7–99·9% aluminium grade 1A, for which the maximum specified silicon content is 0·15%. In practice the silicon content of ingots generally runs between 0·1% and 0·15% and, since there is also some risk of silicon pick-up in melting, a limit of 0·1% would mean that ingots would have to be prepared from super purity aluminium which would, of course, be uneconomical. A reduction of the minimum tensile requirements for the alloy from 14 tons/sq. in. to 13 tons/sq. in. would appear to be a more practical approach to the problem. The field of application of the alloy should not in this way be unduly restricted, since the choice of this material depends very largely on the fact that no complicated heat treatment is necessary. However, whether the tensile requirements are reduced or not, very strict precautions should always be taken to guard against contamination with this element.

TABLE II.—EFFECT OF SILICON CONTENT AND AGEING TREATMENT ON THE PROPERTIES OF D.T.D. 5008 E-TYPE TEST BARS.

Silicon Content (%)	Bars Naturally Aged for:						Bars Artificially Aged for 3 Days at 70°	
	3 Weeks		3 Months		6 Months			
	Indiv.	Aver.	Indiv.	Aver.	Indiv.	Aver.	Indiv.	Aver.
0·1% Proof Stress (tons/sq. in.)								
0·09	7·8 8·3 8·1	8·1	10·3 10·1 9·9	10·1	10·8 10·8 —	10·8	10·7 11·0 11·0	10·9
0·27	8·3 8·6 8·4	8·4	9·6 9·7 10·2	9·8	9·9 10·3 —	10·1	10·1 9·9 10·0	10·0
0·43	8·3 8·0 8·4	8·2	9·0 9·2 9·3	9·1	9·5 9·5 —	9·5	8·7 9·3 8·9	8·9
0·86	7·3 8·0 8·1	7·8	8·4 8·2 8·4	8·3	8·4 8·6 —	8·5	7·7 8·0 7·9	7·9
Tensile Strength (tons/sq. in.)								
0·09	16·7 16·3 16·4	16·5	18·2 18·0 17·8	18·0	18·1 17·5 18·7	18·1	18·3 18·0 17·7	18·0
0·27	15·2 15·3 12·9*	15·3	16·1 16·7 16·0	16·3	16·4 16·4 16·0	16·3	16·4 16·7 16·2	16·4
0·43	14·6 14·1 14·1	14·2	13·4 15·5 14·0	14·3	15·5 15·5 15·3	15·4	14·6 15·0 14·9	14·8
0·86	13·1 11·4 13·3	12·6	13·7 13·4 13·8	13·8	13·7 12·3 13·7	13·2	12·6 13·0 13·3	13·0
Elongation (%)								
0·09	11 13 13	12	10 10 10	10	8 6 11	8	10 10 9	10
0·27	9 9 4*	9	7 9 7	8	7 6 6	6	8 9 8	8
0·43	8 7 6	7	6 7 4	6	7 7 7	7	8 7 7	7
0·86	5 3 5	4	5 4 7	5	4 2 5	4	4 4 5	4

* Inclusion present: result disregarded in calculating average value.

TABLE III.—INFLUENCE OF SILICON CONTENT ON PROPERTIES OF D.T.D. 5008 PRODUCTION TEST BARS NATURALLY AGED FOR 21 DAYS.

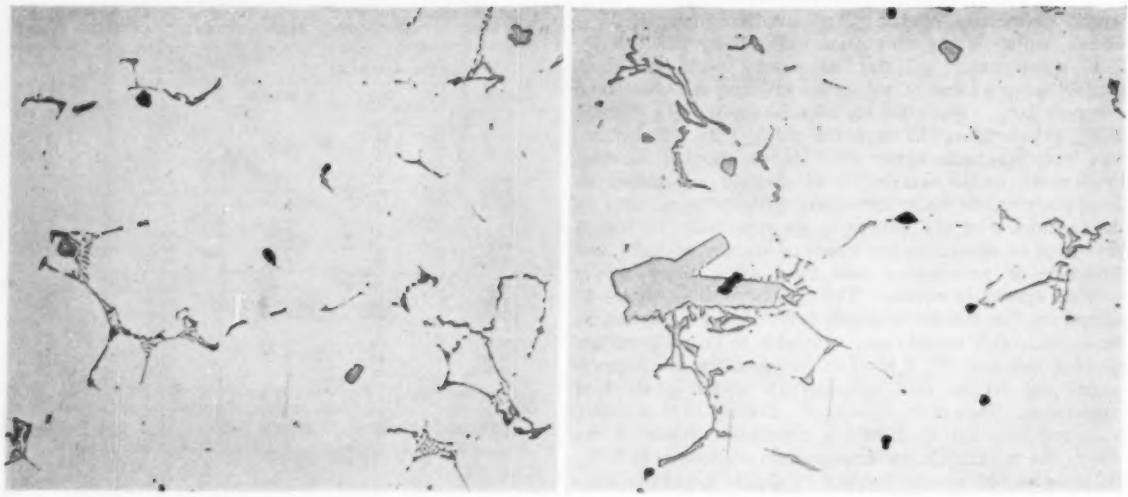
Composition (%)			Tensile Strength (tons/sq. in.)	Elongation (%)
Silicon	Zinc	Magnesium		
0·07	5·28	0·58	14·0	11
0·09	5·57	0·52	14·1	9
0·10	5·13	0·62	14·2	8
0·11	5·18	0·57	14·7	10
0·13	5·34	0·55	14·0	11
0·13	5·34	0·54	13·9	12
0·13	5·03	0·74	14·0	8
0·14	5·09	0·50	14·5	10
0·15	5·31	0·69	15·8	9
0·16	5·10	0·50	14·6	12
0·20	5·19	0·98	14·0	8
0·27	4·75	0·69	14·3	6
0·31	4·80	0·55	13·0	5
0·36	4·92	0·52	12·5	4½
0·40	5·06	0·61	12·2	5
0·41	5·25	0·79	12·5	5
0·54	4·80	0·98	12·1	4
0·95	4·50	0·68	10·4	4

Ageing

The results in Fig. 2 suggest that the natural ageing process is largely completed after three months at room temperature and that longer periods have comparatively little effect on the properties, particularly the tensile strength. Inspection of the last two columns in Table II will show that the same results are brought about by a low temperature tropicalisation treatment of three days at 70° C. after a week's ageing at room temperature. This appears a useful finding since this treatment develops the full properties of the alloy in a shorter time than is required if natural ageing is employed, and it probably has an additional advantage over the standard artificial ageing treatment of fourteen hours at 180° C., although it is longer, insofar as it does not seem to reduce the ductility and strength of the alloy, as is the tendency with the standard treatment. On the other hand, the standard heat treatment imparts much greater resistance to stress corrosion into the alloy than the tropicalisation or the natural ageing treatment, as shown in Table IV.

TABLE IV.—STRESS CORROSION OF D.T.D. 5008 ALLOY[1].

Type of Heat Treatment	Stress Corrosion Life at 90% Proof Stress in Intermittent Salt Spray (days)
(1) Naturally aged for 2 weeks and tropicalised for 3 days at 100° C.	4
(2) Naturally aged for one week and tropicalised for 3 days at 70° C.	4½
(3) Aged 10 hours at 180° C. and tropicalised for 3 days at 70° C.	125



(a) (b)

Fig. 4.—Section of D.T.D. 5008 test bars containing (a) 0·27% and (b) 0·86% silicon. The increase in silicon content coarsened and increased the amount of alpha Al-Fe-Si. Note also the coarse primary $CrAl_7$ in (b). ×150

Summary

Silicon seriously reduces the tensile properties of D.T.D. 5008 and should either be kept below 0·1% or the minimum tensile requirements should be reduced from 14 tons/sq. in. to 13 tons/sq. in.

Tropicalisation treatment of three days at 70° C., although not covered by the existing specification, seems to offer an interesting alternative to the standard treatment of fourteen hours at 180° C., although this has its limitations.

Appendix

Various Composition Specifications for D.T.D. 5008 Type Alloys

Country	Britain	U.S.A.	France
Specification	D.T.D. 5008	ZG61A	A-Z5G
Composition (%)			
Zn	4·8 –5·7	5·2–6·0	4·5 –5·5
Mg	0·5 –0·7	0·5–0·65	0·4 –0·65
Cu	0·1	0·3	0·15–0·35
Cr	0·4 –0·6	0·4–0·6	0·15–0·35
Fe	0·5	1·0	0·8
Ti	0·15–0·25	0·1–0·25	0·15–0·25
Mn	0·1	0·3	0·4
Si	0·25	0·25	0·3
Others	Pb and Sn 0·05 each	Total other impurities 0·15% max.	0·05

Standard Ageing Treatments

(1) Three weeks at room temperature.

(2) Not less than 10 hours at 180 ± 5° C.

Tensile Requirements

	Tensile Strength (tons/sq. in)	Elongation (%)
Sand Cast	14 min.	4 min.
Chill Cast	15 min.	5 min.

Acknowledgments

The author is indebted to the directors of J. Stone and Co. (Charlton), Ltd., for permission to publish this paper.

REFERENCES.

1 U.S. Patent No. 2,146,330.
2 Eastwood, L. W., and Kempf, L. W., *Trans. Amer. Foundrymen's Soc.*, 1948, **56**, 100.
3 Sicha, W. E., and Hunsicker, H. Y., *Trans. Amer. Foundrymen's Soc.*, 1950, **58**, 133.
4 British Non-Ferrous Metals Research Association. Private communication.

G.E.C. (Engineering), Ltd.

A NEW company, G.E.C. (Engineering), Ltd., has been formed to take over and develop the engineering activities of The General Electric Co., Ltd., in accordance with the new policy of the G.E.C. to form its manufacturing groups into subsidiary companies. The manufacturing resources of the new company are at Witton, Birmingham (electrical engineering), and Erith, Kent (mechanical engineering): the total number of employees exceeds 15,000.

The chariman and managing director will be MR. R. N. MILLAR, with MR. T. H. KELSEY as director and general manager at Witton and DR. K. J. WOOTTON as director and general manager at Erith. Other appointments to the board include MR. C. J. O. GARRARD (commercial director), MR. E. NICHOLSON (financial director), DR. H. K. CAMERON (development director), MR. G. M. F. DONNELLY (production director), MR. W. D. MORTON (personnel director) and MR. J. E. THOMAS (secretary).

Atlas Steels Awarded Indian Know-How Contract

ATLAS STEELS, LTD., of Canada, have recently been awarded a contract valued at several million dollars to supply "know-how" and training services to Hindustan Steel, Ltd., in connection with a special steel plant to be set up at Durgapur, India. This plant, which is being engineered by an Indian firm of consultants, is intended to be in operation by 1965. It will produce alloy, stainless and tool steels. Initial output will be about 80,000 tons per annum, with provision for an ultimate capacity 300,000 tons.

The Properties of Tungsten Carbide-Cobalt Alloys Used for Mineral Cutting Tools

By A. Latin, Ph.D., M.Eng., F.I.M.

Head of Metallurgy Branch, Mining Research Establishment, National Coal Board

The work described by the author is a study of factors relevant to the cutting behaviour of cemented carbide hard metals in minerals, special attention being given to abrasion, and to chipping at the cutting edges. The second part of this article deals with the results of the cutting tests and includes a description of some work on the effects of impact. Finally, general conclusions relating in particular to the specification of materials for mineral cutting purposes are given.

(*continued from page 216 of the November issue*)

Results of Cutting Tests

A closely linear relationship was observed between the cumulative loss of weight and the area traversed by the tool tip, as shown in Fig. 6 for various grades with end cuts. Full curves were not taken for all tests, the main results given being for one complete cut. It will be evident that the values obtained approximate to the slopes of the corresponding complete wear curves.

The results for the side cuts are shown plotted against nominal cobalt content in Fig. 7 and against measured hardness in Fig. 8. Those for the end cuts are shown in Figs. 9 and 10, which include results from a wider range of samples than used in the side cut tests.

The chief results obtained may be summarised as follows :—

(*i*) Although the scatter in some cases was considerable, the results were reasonably consistent. It is apparent that the relationships are not linear, the slopes of the curves decreasing with decreased cobalt content and increased hardness.

(*ii*) The increase in wear for hardness values below about 1,200 appeared to be very rapid, the observed values for the 20% cobalt alloys, for example, being possibly too small, as the wear was so rapid that these alloys failed to take complete cuts.

(*iii*) The normal load on the tips in the end cut tests increased with increased wear and the value attained during a test was greater, the greater the wear loss,

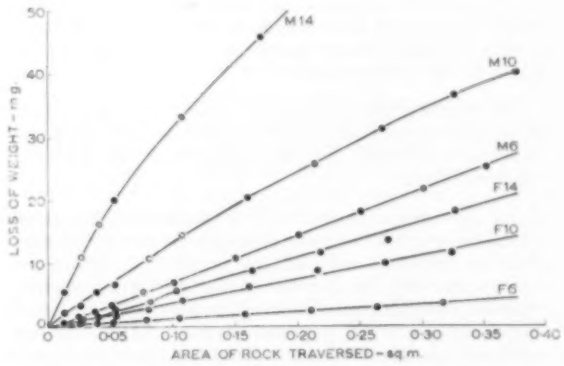


Fig. 6.—Cumulative wear of various grades of carbides—end cuts.

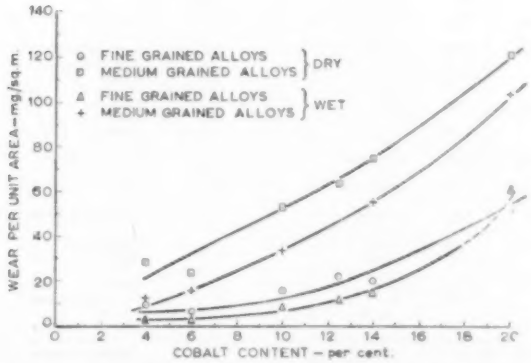


Fig. 7.—Variation of wear with cobalt content—side cuts.

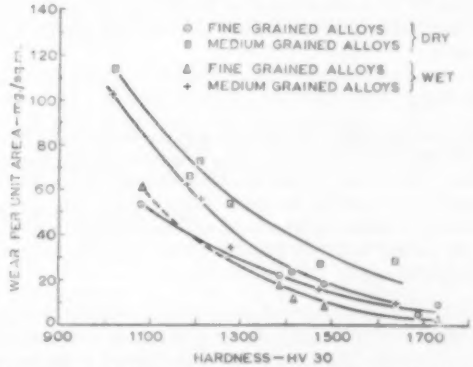


Fig. 8.—Variation of wear with hardness—side cuts.

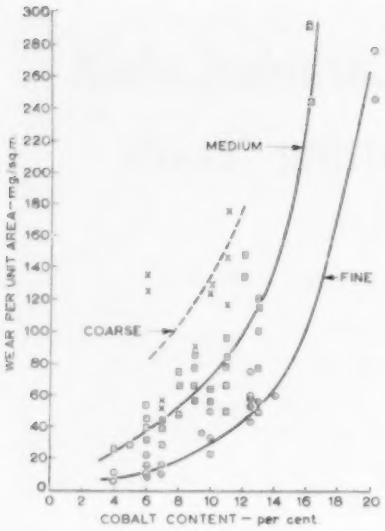


Fig. 9. (left)—Variation of wear with cobalt content—end cuts.

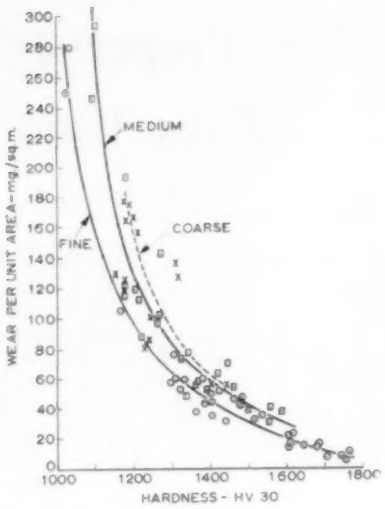


Fig. 10. (right)—Variation of wear with hardness—end cuts.

but no exact relationships were established. The range of attained loads was from about 50 lb. for hard grades retaining their sharpness, to about 200 lb. or more for the softest grades.

(*iv*) Some decreased rate of wear under wet conditions (a water jet above the tip) can be seen from the side cut test results, but little difference was observed with end cuts.

(*v*) The wear rate under given conditions for a given composition (cobalt content) decreased markedly with decrease of grain size (Figs. 7 and 9). This is in agreement with the increase of hardness with decrease of grain size (Fig. 3). However, as both Figs. 8 and 10 show, for alloys of a given hardness there is some evidence of decreased wear rate with decreased grain size, although the effect was not always very marked.

(*vi*) The results of the tests at different speeds and feeds will not be detailed here. For the side cut tests an increase in the rate of revolution, surprisingly, had a pronounced effect in diminishing the observed wear rate, but in the end cut tests an approximately proportionate increase in wear rate was observed, the load on the tip increasing at a given feed. The effect of increasing the feed rate was more complex, there tending to be a maximum at intermediate rates, e.g., at a feed rate of 0·007 in./rev. for an F10 grade, with end cuts.

Impact Tests

There are few data at present available on the effects of shock stresses on carbide tips relevant to the present problem. The most logical method of study seemed to be to subject the carbide to some form of impact against rock, and two main methods of accomplishing this were tried, (*a*) using a direct impact blow, and (*b*) using an impact involving a scraping action.

(*a*) *Direct Impact Test*—This was, in essence, a single blow test. The rock sample is broken, at least at the surface, by each blow and repeated-impact tests would therefore lead to difficulties in the control of the precise conditions at each impact. The test consisted simply of subjecting the sharp-edged carbide sample to a heavy

TABLE II—RESULTS OF DIRECT IMPACT TESTS—120 ft. lb. BLOW ENERGY

Grade	Hardness (HV 30)	Energy Absorbed (ft. lb.)	Total Loss of Weight (mg.)	Degree of Chipping
F4	1740	30, 21	63	Considerable
	1776	29	Fr*	—
F6	1676	27, 15	17	Considerable
	1769	60	Fr	—
	1730	12, 9	14·3	Considerable
	1733	16	3·2	Small
		15	Fr	—
	1655	43	Fr	—
F7	1591	21	Fr	—
	1587	30, 16	88	Considerable
F10	1536	13, 7	9	Small
	1501	68, 23	9	Considerable
	1463	33	Fr	—
	1454	90	0·1	Very little
	1431	68	3	Small
F12	1438	76, 15, 120, 120	6	Impact-abrasion
	1434	6, 24	1	Slight
	1377	20	1	Slight
	1405	59	0·3	Slight
F14	1419	10, 11, 58	1	Impact abrasion
	1403	27, 17, 120	Fr	—
F20	1156	59, 14, 14, 120	7	Impact abrasion
	1043	44	2	Impact abrasion
M4	1643	27	Fr	—
	1628	17, 7	10	Considerable
	1557	82	Fr	—
M5	1528	12, 10	5	Small
M6	1523	38, 12	23	Large number of small chips
	1483	21, 17	4	Small
M7	1529	35	2	Small
		56	Fr	—
	1520	71	2	Small
M9	1450	7, 71, 120	4	Impact abrasion
M10	1290	19, 14, 120, 120	6	Small
M11	1372	5, 70, 67	2	Impact abrasion
M12	1203	38, 10	9	Considerable
	1198	33, 18	4	Small
M14	1219	22, 9	3	Small
	1226	30, 7	0·5	Impact abrasion
M20	996	24, 9, 42	3	Impact abrasion
C9	1250	12, 93, 15, 53, 56	3	Impact abrasion

* Fr = Fracture.

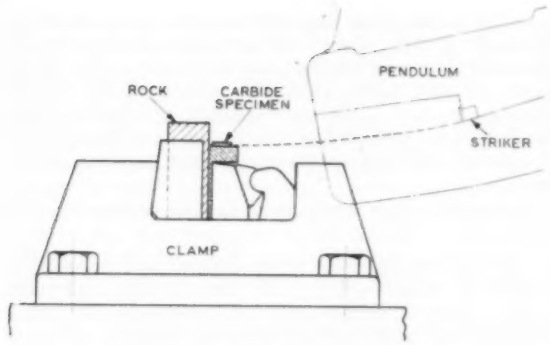


Fig. 11.—Apparatus for direct impact test.

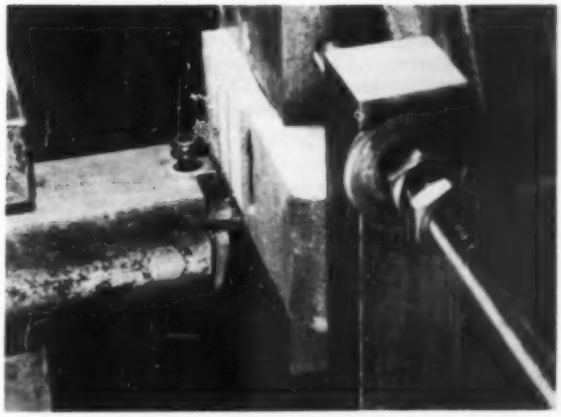


Fig. 12.—Impact scraping test arrangement.

blow which caused it to strike against a suitable piece of rock. The carbide sample was placed on a stand in front of the piece of rock, held in the clamp of an Izod testing machine, with the sharp end carefully parallel to and at a distance of 0·025 in. from the face of the rock. Pennant sandstone, a hard consolidated stone, was used since it has usually a considerable resistance to fracture. The carefully cut rock samples were of rectangular section $1\frac{1}{2}$ in. thick, and of a height of $2\frac{1}{2}$ in., of which $\frac{3}{4}$ in. protruded above the clamp. A diagram of the arrangement is shown in Fig. 11. The blow was applied by the swing of the pendulum, and the absorption of energy measured in the usual way by means of the pointer and scale on the machine. Strain gauges were in some tests attached to the carbide specimen for recording the compressive loads and bending stresses. Up to five blows were made, using the same carbide specimen but fresh rock samples. Two main series of tests were run; for one the energy of blow was 120 ft. lb., for the other it was 35 ft. lb. The higher energies usually resulted in complete fracture of the rock sample, the smaller blow energies did not. The loss of weight of the carbide samples was measured, and note taken of the frequency and form of any chipping that occurred.

TABLE III.—RESULTS OF DIRECT IMPACT TEST—35 ft. lb. BLOW ENERGY

Grade	Hardness (HV 30)	Total Loss of Weight (W)(mg.)	No. of Blows (N)	W/N	Mean Peak Compressive Load (tons)
F4	1838	13·9	5	2·77	1·9
		38·5	3	12·8	—
F6	1749	35·7	5	7·10	2·0
	1643	0·4	5	0·10	1·6
	1646	Fr*	2	—	2·1
F7	1688	Fr	3	—	1·6
F10	1526	16·4	5	3·27	1·7
	1510	9·3	5	1·87	1·6
	1452	7·03	1	7·03	—
	1429	Fr	5	—	2·1
	1407	8·64	5	1·73	0·6
	1424	2·2	5	0·44	—
	1438	29·1	5	5·82	—
M5	1532	1·17	5	0·23	2·3
M6	1474	0·58	5	0·12	—
	1454	0·43	5	0·09	1·8
M7	1489	35·9	5	7·2	2·8
	1504	Fr	5	—	3·0
M9	1377	3·06	5	0·34	1·0
	1374	3·06	5	0·61	1·1
M10	1354	1·37	5	0·27	—
	1254	1·6	3	0·53	—
M12	1258	3·15	5	0·63	1·3
	1238	5·88	5	1·18	1·8
C4	1370	Fr	1	—	3·0
	1341	1·12	5	0·22	1·5
C11	1234	2·52	5	0·5	1·8
	1224	12·1	5	2·43	2·0

* Fr = Fracture.

(b) Impact Scraping Test—A rectangular piece of Pennant sandstone rock was held rigidly on a face plate of a lathe at between 6 in. and 7 in. from the centre. The carbide specimen, with its cutting edge sharpened as before, was held firmly in a holder in the tool post of the lathe and fed forward at a known rate to make contact with the sandstone at each revolution. The arrangement is shown in Fig. 12. It was found that consistent flaking or chipping of the face of the carbide specimen could be obtained when the face plate was rotated at suitable speeds and the rotation was such that the sharp edge of the carbide specimen was trailing. Some tests were carried out at slow speed (7·5 rev./min. corresponding to a linear speed of 5 in./sec.) and some at a relatively high speed (107 rev./min. corresponding to a linear speed of 5·8 ft./sec.). In each case a forward feed of carbide specimen of 0·017 in./rev. was used. In the slow speed tests three successive blows were allowed to take place and in the other, two impact blows during each test All samples tested showed some chipping after the first or second blow, and it was found that, once chipping occurred, subsequent loss of material was the result of abrasion only, and was insignificant compared with that due to chipping.

The chipping obtained by this method occurred on the face of the specimen and, although less marked, was similar in appearance to that sometimes seen on coal or stone drilling bits used in service, being of flaky form with a conchoidal fracture surface.

Results of Impact Tests

(a) The chief results of the direct impact tests are tabulated in Table II for the 120 ft. lb. blow, and in Table III for the 35 ft. lb. blow. In Table II the loss of weight from each blow and, where the test was repeated, the cumulative loss of weight are shown. An indication of the severity of chipping is also shown for this first set of results; in no case, however, were the flakes at the

front edge greater than 5 mm. in extent, and they were always extremely thin. In the second series little face chipping occurred. The total loss of weight and the mean loss per blow are shown in Table III ; also the peak compressive load, where recorded.

The results from these tests can be summarised as follows :—

(*i*) There was considerable variation in behaviour, but on the whole the incidence and degree of chipping or of fracture was greatest for the fine-grained materials of high hardness, and decreased with increased cobalt content and decreased hardness.

(*ii*) Large variations occurred in the energy absorbed in fracture of the rock ; no clear correlation was obtained between this energy and the chipping or fracture occurrence in the carbide. Although the general effect of increased energy absorption was to increase the damage, even small energy absorptions appear to have led to considerable chipping or to fracture of the more brittle grades.

(*iii*) For the fine-grained alloys with cobalt contents above about 10%, and hardness of less than about 1450 HV, burring or a form of abrasion of the carbide edge rather than chipping occurred. In some cases this edge abrasion had an appearance of very fine micro-chipping, although different from the smooth conchoidal fracture obtained in ordinary chipping.

(*iv*) For the coarser-grained alloys, the same is broadly true for compositions of about 6% cobalt and above.

(*v*) In the lower energy tests the compression load varied considerably ; a maximum load of 1–2 tons was in general obtained. Maximum bending stresses were about 30 tons/sq. in. The duration of impact was about 0·3–0·5 millisec.

TABLE IV.—RESULTS OF IMPACT SCRAPING TESTS AT LOW SPEED
(Result of three impacts ; speed of rotation = 7·5 rev./min.; linear speed = 5 in./sec).

Grade	Hardness (HV 30)	Loss of Weight (mg.)
F4	1817	204·8 Fr*
F8	1736	44·0
	1634	26·4
F7	1685	10·7
	1661	106·6
	1664	Fr
F10	1458	17·3
	1436	6·1
	1548	17·9
F12	1373	16·4
	1304	3·2
	1322	2·1
M6	1488	23·9
M7	1509	155·2
	1504	222·9
M8	1458	22·0
M9	1372	34·2
	1368	1·7
M10	1372	37·2
M15	1178	16·2
M20	1094	13·5
C4	1377	12·5
	1354	34·3
C11	1234	2·8
	1234	2·4

* Fr = Fracture.

(*b*) The results of the impact scraping tests are shown in Tables IV and V. The former tabulates the cumulative losses for three impacts on each specimen at the lower speed and the latter gives the results at the higher scraping speed. In this, the maximum and mean weight losses, also the standard deviation, for a number of tests on several different specimens of each nominal grade are given.

The results from these tests can be summarised as follows :—

(*i*) The amount of chipping showed some correlation with the cobalt content. It will be seen that there was a general decrease of both maximum and mean weight loss with increase of cobalt content, although considerable variations occurred. The apparent discrepancy between the results shown in Table V for the 10% cobalt and 12% cobalt fine-grained materials is due to one result showing a particularly high loss for the latter composition. Evidently there is some probability of high weight loss, even at this relatively high cobalt content, but the probability must in general decrease with increased cobalt content Similar considerations apply to the apparent discrepancy between C9 and C11.

(*ii*) The variability of the results was doubtless partly connected with quality variations. Some of the results on sets of samples from individual manufacturers were more consistent than others, but it has not been possible to establish any definite functional relationship between composition and chipping loss.

(*iii*) The effect of grain size variation appears in these tests to be less marked than the effect of composition. However, the maximum weight losses due to chipping were obtained with the low cobalt (in particular 4% and 6%) fine-grained materials. Comparison of grades F9, M9 and C9 (Table V) indicates a decrease of weight loss with increased grain size, although the effects are less clear and less marked at higher cobalt contents.

(*iv*) A general decrease in liability for chipping with decrease in hardness was obtained.

Transverse Rupture and other Tests

Some transverse rupture tests were carried out on specimens 1·5 in. long × 0·16 in. square using the apparatus of Penrice and Shute[25], in which four-point bending is applied. Most of the specimens were in the

TABLE V.—RESULTS OF IMPACT-SCRAPING TESTS AT HIGH SPEED
(Maximum and mean values of loss of weight ; speed of rotation = 107 rev./min.; linear speed = 5·8 ft./sec.)

Grade	Total No. of Tests	Loss of Weight (mg.)		Standard Deviation
		Max.	Mean	
F6	12	243·5	43·3	69·3
F7	16	36·4	9·5	7·9
F9	5	56·0	20·6	19·2
F10	15	26·4	8·0	6·5
F12	19	56·2	8·7	11·4
M6	6	83·2	25·4	22·0
M7	3	112·2	47·0	—
M8	6	83·3	23·8	32·5
M9	10	14·7	6·9	23·1
M11/12	12	11·1	5·1	2·6
M13	4	7·7	5·5	2·0
M15/16	6	6·4	5·0	1·4
C4	3	122·7	46·9	—
C9	7	8·0	4·5	1·4
C11	7	27·9	8·0	8·2

as-sintered condition, although some were polished. The results obtained were of the order of those on similar materials published elsewhere[9,10] but showed considerable variation, possibly due to surface condition. Values ranged from 80 tons/sq. in. for the hardest grades to 115 tons/sq. in. for the softest grades, but no definite correlation with other properties such as chipping behaviour could be ascertained. The mode of fracture varied considerably. Plane surfaces perpendicular to the axis of the specimen, but frequently bifurcating, were obtained with the harder grades, and non-planar surfaces, indicating some plasticity, with the coarse-grained materials.

Some studies have been made of the mode of cracking in the carbide samples examined but will not be detailed here. They have given some indication of an increase in resistance to cracking with increase of grain size at a given hardness level.

Coercivity measurements were made on a large number of the samples but the results again need not be detailed here. Some correlation with abrasive wear properties was obtained but little correlation with toughness factors.

Discussion of Results

It will be seen from the results of the measurements of hardness and density that a considerable variation in quality of the carbides apparently occurred, there being a considerable spread of values for given nominal grades. The micro-examination and grain-size estimations gave some explanation of this. The predominant grain-size of nominally fine-grained alloys varied from 1 micron to as much as 3 microns, whilst for medium-grained grades a variation of from 2 to 4 microns or more was found. Some of the coarse-grained materials did not differ greatly in grain size from some of the medium-grained materials, whilst others contained very large grains, the overall range of grain sizes being from about 3 to over 6 microns.

Abrasive Wear

At given cobalt contents the wear loss values for the fine-grained alloys were well below those for the medium and coarse-grained alloys. More significant, however, was the very rapid increase in the wear rate for cobalt contents above about 14% in the fine-grained alloys and about 12% in the coarser-grained alloys. The relationship between wear rate and cobalt content appeared indeed to be more nearly exponential than linear. This rapid increase in rate of wear with increased cobalt content in the higher range of cobalt contents was probably partly the result of the test conditions and can, to a certain extent, be accounted for by the high loads reached with the softer materials. Thus, for example, for F10 a load of about 70 lb. was reached but for rapidly wearing grades loads of over 200 lb. could be attained. This is probably simply due to the normal load between the carbide tip and the rock increasing for a given penetration speed (i.e. lathe feed setting) with increased wear of the tip.

The rapid increase in wear rate at the high cobalt contents may also be partly a result of increase of temperature. It is possible that in these test conditions a considerably higher temperature is reached at the cutting edge with the softer materials than with the harder materials, which cut the rock more easily. Whilst no sudden softening of tungsten carbide materials takes place at increased temperatures, there is a general decrease of hardness with temperature, as pointed out above. It is possible that temperatures of a high order may be reached at the cutting edge, but it has not been possible to carry out any determinations in these tests.

Although there was a fair spread of results, the fairly close correlation of wear with hardness is of considerable value in enabling approximate estimates of relative wear to be gauged from hardness determinations alone. However, such estimates must be made with caution, as their usefulness is likely to depend upon the exact conditions to which the tool tip is subjected in practice, in particular as affects the order of and nature of the applied forces.

The relationship between wear resistance and the approximated calculated mean free path between the carbide grains (Table I) appears to be more nearly linear than those between wear and composition or hardness, at least for the results of the side cut tests. However a rapid increase in wear loss for the higher values is still indicated.

The results obtained help, perhaps, to give some insight into the mechanism of the abrasive wear by rock, etc., of cemented carbides. Two main effects are suggested: (*i*) cutting or shear abrasion by hard and probably sharp quartz particles; and (*ii*) crushing abrasion under compressive forces. The first effect is probably the main one in the side-cutting tests and may account for the effect of grain size. The main cutting action by the quartz must be on the softer cobalt phase, this firstly being removed, followed by displacement of the hard particles. The improved abrasion resistance of the finer grained material at given hardness level then probably follows from the increased resistance to cutting of the thinner cobalt films. In the end-cut test conditions, crushing abrasion is more important, possibly involving fracture of the carbide particles themselves and the effects of the grain size are consequently less marked.

Chipping and Fracture Characteristics

The results of the direct impact tests have indicated an increased liability to chipping and to failure by fracture of the fine-grained materials below about 10% cobalt content. In general the materials having cobalt contents above 10% withstood the test conditions remarkably well.

Of special interest in the study of the chipping characteristics are the results of the tests in which combined impact and scraping effects occurred. The operation of the test so that the cutting edge was trailing may at first sight appear to differ from that in normal rock cutting and drilling processes, but the face chipping effect produced was very similar to that which can occur in practice. It is possible that, in practice, an equivalent action in effect occurs as the result of reflected shock waves in the carbide tip, resulting in momentary stress distributions at the cutting edge similar to those operating under the test conditions. The large scatter of values is obviously the type of effect to be expected.

From the results it seems clear that for fine-grained alloys the material loss in any given incidence of chipping is likely to increase markedly for cobalt contents below about 10%, whilst for medium-grained material, the loss is not likely to be as great as the maximum values obtained in fine-grained material. The differences

between the coarse-grained and the medium-grained material would appear to be less marked.

No exact correlation with the values of the mean free paths between the carbide grains was obtainable from the results, although a general increase in resistance to chipping is observable with increase in the mean free path.

Little difference in chipping propensity could be observed for all grain sizes above a cobalt content of about 10%, although there is some indication that fine-grained material of cobalt content up to as much as 12% can exhibit a considerable weight loss due to chipping. The indications are that this was comparatively rare under the test conditions concerned and may be connected with some variation in quality.

It is possible that more onerous conditions could be devised that would increase the liability to chip of those materials which, under the present test conditions, have not shown such liability to any marked extent. It is, nevertheless, certain that the actual conditions of test are equivalent to quite stringent practice. This being the case, the use of a fine-grained alloy of moderately high cobalt content (say 12·5%) can be favourably compared with that of coarse-grained alloys of lower cobalt content. There can be little doubt, however, that hardness in itself, irrespective of grain size and composition, is an important factor, liability for chipping decreasing with decreased hardness.

Conclusions

A wide range of carbide materials of various cobalt contents and grain sizes have been examined, and relationships have been sought between grade variables and the resistance to abrasion and to chipping in the cutting and working of rock, with results as follows :—

(*i*) Cutting tests on Darley Dale sandstone with sharp-edged carbide tool tips have shown an approximately linear relationship between wear, as given by loss of weight, and amount of cut, as expressed by the area of rock traversed by the carbide tip.

(*ii*) Tests under standardised conditions have shown the rate of abrasive wear of tool tips on the sandstone to increase rapidly above certain cobalt contents ; about 14% for fine grained (approximately 1–2 microns grain diameter) alloys and 12% for alloys of medium grain size (approximately 2–4 microns diameter). The values for carbide tips from various sources were in general agreement with their cobalt contents and measured predominant grain sizes.

(*iii*) A correlation between wear resistance and hardness has been found, with some spread of values due to variations in grain size (a fine-grained alloy having apparently better wear resistance than a coarse-grained alloy of the same hardness), and to other quality factors. A rapid decrease of wear resistance occurs at hardness values below about 1200 (HV 30).

(*iv*) Owing to the rapid blunting of the tips of the softer grades, greatly increased loads are required for cutting. The use of material of the maximum hardness consistent with resistance to chipping is therefore desirable for purposes where impact is not too great.

(*v*) Studies of chipping characteristics of sharp-edged carbide specimens by impact and by scraping against rock have shown that the liability for chipping and the maximum loss of material in any occurrence of chipping are dependent upon cobalt content and grain size, especially for cobalt contents below about 10%. There appears to be some correlation with hardness as such, but also some indication that at a given hardness level the coarser grained alloys may be the more resistant to forms of brittle failure.

(*vi*) Transverse rupture tests have shown no close relationship with face-chipping characteristics.

(*vii*) Approximate calculations have been made of the mean free paths between the carbide grains in the various grades examined, and some correlation between these values and the resistance to wear has been observed. Wear loss rate appears to increase with increase of mean free path rather more linearly than with increase of cobalt content or with decrease of hardness. Little exact correlation appears to exist between mean free path and chipping propensity, although increase in the mean free path appears to lead to increase of toughness.

(*viii*) Concepts of abrasive wear which are suggested from the results of this work are that : (*a*) a cutting action, probably by sharp quartz particles, is involved which is sensitive to the effects *per se* of the grain size of the carbide particles ; (*b*) a crushing abrasion occurs which is less sensitive to intrinsic grain size effects ; (*c*) softening effects occur at the tip due to the development of high temperatures ; and, (*d*) possibly chemical interactions occur with reactive constituents of the mineral matter.

The results of these various tests and of the examination of material as used in practice have enabled specific proposals to be put forward as regards optimum carbide grades for rotary and percussive drilling in coal or stone as well as for coal cutting and for rock tunnelling machine tools. The composition used depends upon judgment of the desired combination of hardness and toughness. Thus for rotary drilling in coal of hard but uniform quality, cobalt contents as low as 7% with hardness up to 1550 (HV 30) can be used for the carbide tip. A useful general purpose composition contains 10% cobalt and is of fine grain size. For coal containing many inclusions or intrusions and for stone, cobalt contents as high as 13% may be needed with hardnesses as low as 1300 (HV 30). For coal cutter picks and rock tools of other kinds, coarser grained materials with cobalt contents ranging from about 9% upwards may be required. These tougher grades may also be required for drilling in rocks of difficult nature containing hard intrusions or bands, especially where high penetration rates are desired. As pointed out above, however, the loss in abrasion resistance is such that hardness values below 1200 (HV 30) are from this point of view undesirable.

These proposals are in good agreement with the grades for mining purposes described by Schwarzkopf and Kieffer.[28] The results of the examination of the behaviour of different grades of samples as used in service also confirmed these findings. Obviously quality considerations are also highly important.

It is possible to suggest the basis for a more quantitative assessment of optimum grades from this work. This could be achieved if suitable functions of, for example, composition could be given for losses by abrasive wear and by flaking or chipping, respectively.

Representing composition (% cobalt) by x, the total loss at the cutting edge is given by the sum of the corresponding values of the two functions, each multiplied by a factor representing liability to abrasion and to chipping, respectively, under the given conditions, i.e.

$$\text{loss} = mf_1(x) + nf_2(x)$$

where $f_1(x)$ is the abrasive wear function, etc. The proportion of the first factor to the second is large for conditions of high abrasion, such as drilling at slow penetration speeds in hard uniform coal or stone, and small for conditions of shock, etc., leading to increased liability for chipping. If m, n are assumed practically constant for given cutting conditions, then it follows from differentiation and equating to zero that minimum loss is given by

$$f_1'x/f_2x = -n/m.$$

Solution of this equation gives the optimum value of x.

There are of course many complications, but it is hoped that further work may lead to the establishment of a suitable function (or set of functions) for both forms of cutting edge loss, as well as suitable values for m and n (or their ratio) under different conditions.

Whilst the present work has advanced the understanding of the technology of carbide tool materials as applied to coal mining and related purposes, further work on various factors concerned would be desirable. In particular, further detailed studies of quality factors (presence of free graphite, cobalt distribution, grain-size distribution, effects of impurities and special additions, etc.), with particular regard to their effect upon toughness or resistance to brittle behaviour, would be of value. Also needing further study are the effects of grain-size blending, and such processes as vacuum sintering and, possibly, hot pressing. In practical applications the design of tool and the method of mounting the tip are also of great importance. A detailed programme of work on these aspects, complementary to the metallurgical work, is in hand in the Mining Research Establishment.

Acknowledgments

The author wishes to express his indebtedness to his colleagues, in particular Mr. S. R. Williams, for his assistance in this work; also his gratitude to Dr. L. C. Tyte, Director of the Mining Research Establishment, for his encouragement. Acknowledgments are also due to the several firms consulted regarding carbide products, for their great helpfulness. The work described was carried out as part of the research programme of the Scientific Department of the National Coal Board and is published by permission of the Director General of Research.

REFERENCES

25 Penrice, T. W., and Shute, D. H., "Symposium on Powder Metallurgy, 1956," Iron and Steel Institute, Special Report No. 58, 277.

26 Schwarzkopf, P., and Kieffer, R., "Cemented Carbides" 1960. New York, Macmillan, 250 *et seq.*

Rolling Mill Programming System

A NEW automatic programming system for steel rolling mills, developed by the metal industries division of the English Electric Co., Ltd., uses punched cards to store "rolling programmes," the complete sequence of screw-down, manipulator and mill speed settings, and the number of passes in a rolling operation. The system is an advance on the uniselector system introduced by the company two years ago, in that it offers a greater programme storage capacity than can be economically obtained with uniselectors. The benefits are the same: the operator, relieved of the routine rolling can do his job better and more easily, producing during his shift more steel of more consistent quality. He can always take manual control to correct rolling faults. The first installation of the new system is at the Hallside works of Colvilles, Ltd., where it controls the screwdown on the reversing billet mill.

The complete system consists of three basic units: a card store, a card punch and a card reader. The cards, of tough plastic $\frac{1}{32}$ in. thick, can be supplied in nine different colours, each with an identification tab. The front end of the card is notched and the special storage case holds 100 cards. The keys of the hydraulically operated card punch remain depressed so that they can be checked before a complete line is punched. Cards can be punched to user's specification if a punch is not required.

All the information necessary for one pass of the mill may be stored on a double line on the card, which is advanced section by section for each pass. This method of operation avoids the need for an intermediate memory store, since the pass information remains under the reader for as long as it is required. The sensing devices are photo-transistors, the output from which is amplified by a transistor amplifier controlling a small plug-in relay. The relay operates the various position control systems. All components except the relays are mounted in a standard plug-in Datapac unit of the printed circuit type: faulty units can be located by a test card. There is a parity check on all operations.

A card can be advanced through the reader either by single passes or as a complete rolling operation. After completing the programme the card resets automatically to be used again or rejected, as required.

£54,000 Orders for AEI Motors

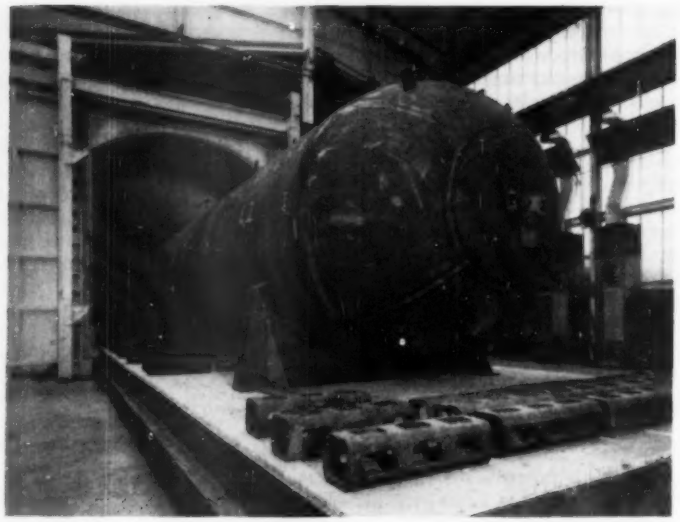
ORDERS totalling £54,000 for electric motors for use in a steelworks extension scheme in Turkey and a British refinery are announced by Associated Electrical Industries, Ltd. The motors will be supplied by the company's motor and control gear division. Burla Biraderler of Istanbul has placed a £24,000 order for both A.C and D.C. electric motors in connection with the extension scheme at Karabuk steelworks, and flameproof high-speed electric motors worth £30,000 have been ordered for the new B.P. California aromatics plant being built at the British Petroleum Company's Kent oil refinery.

Canning's Scottish Branch

W. CANNING & CO., LTD., have opened a Scottish branch at 33 Squire Street, Whiteinch, Glasgow, where stocks are held of a wide range of electroplating chemicals and metals, polishing materials, brushes and lacquers. A well equipped laboratory is in operation and technical service is available. Regular delivery services from Birmingham will continue and the branch is equipped with Telex facilities for direct communication with head office in Birmingham.

Gas-Fired Stress-Relieving Furnace

200 ton Capacity Dowson & Mason Unit for Whessoe



A TOWN'S-GAS-FIRED bogie-hearth stress-relieving furnace recently commissioned in the Darlington works of Messrs. Whessoe, Ltd., is believed to be the largest of its type in the British Isles, and probably in Europe. Supplied by Dowson and Mason Ltd., it is designed to stress-relieve welded fabrications at temperatures between 600 and 650° C. and perform other heat treatment operations up to a maximum of 1,150° C. The internal dimensions are 18 ft. wide, 21 ft. 9 in. high from the top of the bogie to the crown of the furnace arch, and 85 ft. long between the door faces.

In large furnaces, there is a considerable build-up of pressure in the upper portion of the chamber, due to the great height and the temperatures of operation (up to 1,150° C.). It is important that gases should be prevented from escaping from the top and upper sides of the furnace doors, and for this reason, sand-seal troughs are arranged across the top of the roof at the door faces and dipper castings on top of the doors complete the seals. At the sides of the door openings, there are asbestos insulation sealing pads, and both doors when in the closed position are clamped by hydraulic cylinders, since tightening by hand would not be very satisfactory.

It is also important in very large furnaces to prevent the ingress of air from below the bogie, and for this reason, fixed sand troughs are arranged along the sides, with dipper castings in the furnace walls making the seals. Hinged sand troughs at each end are raised by cams to make seals at the bottom of the doors. This allows the bottom of the bogie to be open from end to end, in order to keep the wheels and axle boxes cool. The bogie is moved by a wire cable haulage gear driven by a 25 h.p. electric motor. To reduce tractive effort, roller bearing axle boxes are used and the wheels are disposed alternately in four rows to ensure that the maximum charged weight of 200 tons is evenly distributed.

The walls, roof, and doors are lined with insulating refractory, as its low thermal storage gives considerable fuel economy in the intermittent heat treatment processes on which this furnace will be operated. A frequent problem encountered in the design of large furnaces is that of preventing the walls from collapsing inwardly. Such collapse is impossible in this furnace, because taper wedge bricks are used at intervals along the sides and in the doors. These are held to the casing by vertical rods passing through holes in the bricks. Dowson and Mason have pioneered this method of construction over a number of years.

The town's gas of 475 B.Th.U./cu. ft. calorific value is supplied to multiple horizontal and vertical burners located in the base of the side walls to achieve close temperature uniformity. Nozzle mixing is used for the horizontal burners and those firing vertically give luminous flames. Air is provided by a 10 h.p. electrically driven fan. Twenty-two flues are arranged in each side wall, rising from hearth level to common ducts along the roof, connected to two damper-controlled flue stacks, which exhaust the spent gases above the building roof.

Temperatures are automatically controlled in six zones, each having a Kent pneumatically-operated fully-proportioning recording controller. There are three 6-point strip chart recorders connected to thermocouples attached to the charge and in the furnace atmosphere. A pressure control instrument is provided and gas consumption is recorded by a flowmeter. All instruments are mounted on a cubicle type panel.

Heating a 72½ ton charge to 650° C. in 9¼ hours and soaking at temperature for 2¼ hours requires 200,000 cu. ft. of gas. A 55½ ton charge heated in 12 hours and soaked for 4 hours requires 270,000 cu. ft. The total maximum burner capacity is approximately 40,000 cu. ft./hr. and is capable of heating average charges at a much higher speed than indicated by the figures given. The rate of heating is governed by the cams of the programme control instruments, which can be cut to suit any desired heat treatment cycle.

THE POWER-GAS CORPORATION, LTD., a member of the Davy-Ashmore group, has been awarded the contract by the North Thames Gas Board for a 60 million cu. ft./day continuous reforming plant.

Problems and Possibilities of X-Ray Fluorescence Analysis in the Study of Aluminium and in particular Aluminium Casting Alloys*

By H. Kessler and H. Rammensee

Laboratory of Aluminiumwerke Nürnberg G.m.b.H.

Problems are raised when analysing aluminium and especially aluminium casting alloys by the X-ray spectrographic method, as oxide layers reduce the intensity of fluorescence and primary silicon crystals in hypereutectic aluminium-silicon alloys produce breaks in the calibration curves. The paper discusses the possibility of measuring the thickness of oxide films and of determining the degree of modification by means of X-ray spectrography.

IT is stated in published papers[1,2] and technical courses[3] that various materials, particularly alloys, can be analysed with a high degree of accuracy by X-ray fluorescence analysis after adequate calibration of the instrument with accurately known standards. The instruments available for this purpose[4] have aroused considerable interest, as the aim today is to develop more rapid and more accurate methods of analysis. Analytical results are produced much more quickly by X-ray fluorescence spectroscopy than by wet chemical methods of determination, and X-ray fluorescence has advantages over spectrochemical analysis in that it requires less calibration work, and in that the excitation X-rays and the resulting fluorescence do not damage the samples. With new methods it is, however, necessary to check their suitability for use with the material concerned.

The case of aluminium and its alloys—particularly casting alloys—shows that a number of problems call for clarification before the method can be generally used in practice. Exploratory tests have shown that, apart from straightforward analysis, the technique may find application in the determination of other properties. Some observations which require further study are described below.

Surface Condition of Aluminium and its Alloys

In any condition found in practice, aluminium is covered with a thin oxide film. This film, which is present also on the molten metal, will be thicker in the form of a casting skin directly after solidification than after the castings are machined. Oxide films will thicken again when the metal is stored for a certain time in an atmosphere which favours oxidation. Weakening of fluorescent radiation, which sometimes can be considerable, is known to be produced in elements of low atomic number by the oxygen as well as the nitrogen in the air. It may therefore be assumed that the oxide films present on aluminium also weaken the radiation on account of the oxygen present in the aluminium oxide. In order to study more closely the absorption which it is difficult to show on thin oxide films, films of varying thickness were produced on carefully analysed alloy specimens of the same composition by anodising for different periods of time. Any influence of the oxide films was to be determined by the change in the intensity of the fluorescence for various alloying elements such as magnesium, silicon, iron and copper. It was found that, depending on the thickness of the oxide films, which was stated in terms of the anodising, a change occurred in the fluorescent radiation ; the radiation showed a continuous decrease for the alloying elements magnesium and iron (Fig. 1), whereas for the silicon and copper contents, jumps occurred which have not yet been completely explained.

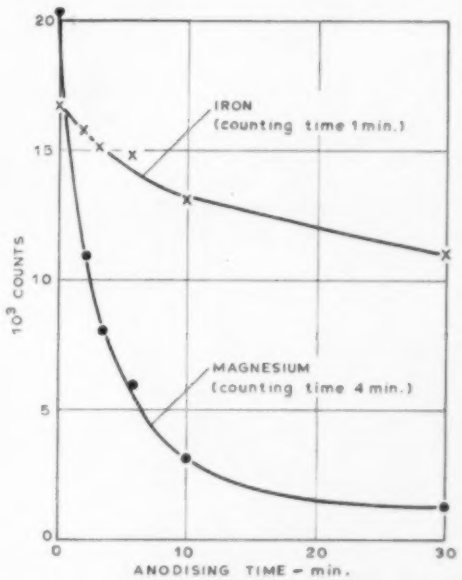


Fig. 1.—Relation between intensity of fluorescence and oxide film thickness obtained in unit time.

It has not yet been possible to state precisely the reasons for the observed effects. It is, however, proposed to point out the phenomena—as yet not fully understood—which at present prevent the X-ray fluorescence method from being used for the study of aluminium alloys and make further measurements necessary. For

* The article was first published as " Probleme und Möglichkeiten der Röntgenfluoreszenzspektroskopie bei der Untersuchung von Aluminium, insbesondere Aluminiumgusslegierungen" in *Zeitschrift für Metallkunde*, 1960, **51** (9), and was translated from the German by H. B. Nowottny.

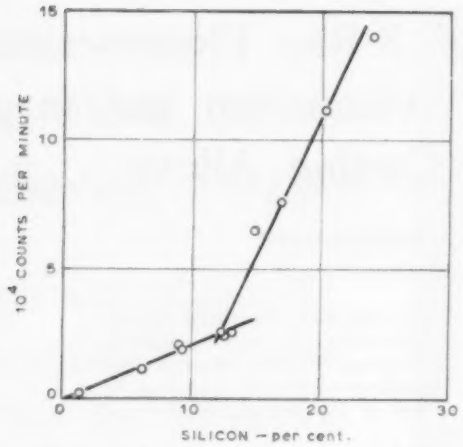


Fig. 2.—Showing the different intensity of silicon fluorescence in the hyper- and hypo-eutectic regions of aluminium-silicon alloys.

instance, to discuss the jumps in the measured intensity of fluorescence for copper, which occur at different thicknesses of the oxide film, it will be necessary to study oxide films produced, not by the D.C. sulphuric acid method, but by other conventional methods of anodising. In this way attack and dissolution of copper atoms, in precipitates and possibly in solid solutions, by the electrolyte should be eliminated. Similar considerations apply also to silicon.

An earlier view[5] should not be disregarded; here it was found that protracted anodising not only inhibits further growth, but even leads to the removal of certain oxide films and to irregular porous loosening of regions of other films. These processes occur precisely in the thicker oxide films produced by anodising over long periods, and they are confirmed by irregularities of the X-ray fluorescence observed on samples with such films. For artificially produced anodic films, it has been proved that an influence on the intensity of the fluorescent radiation exists, and this influence must be effective also in thin anodic films formed under atmospheric conditions. On the basis of this result, fresh specimens, with surfaces prepared if possible in vacuum or an inert gas atmosphere, should always be used in the fluorescence analysis of aluminium specimens. The examination of specimens can also be carried out at an accurately fixed interval after the surface treatment, to avoid the trouble involved in storing the specimens in air-conditioned space and in an inert gas atmosphere to eliminate oxidation. This implies that the standard specimens also, which in this method have an indefinite life since they are not destroyed in the analysis, must first be restored to the specified surface condition when used for repeated examination.

Determination of Anodic Film Thickness

It follows from the above considerations that the thickness of the oxide film present on aluminium alloy surfaces influences the absorption of fluorescent radiation. Conversely, if the alloy composition is known precisely it must be possible to determine with great accuracy the thickness of the oxide films present on the aluminium, by observing the weakening of the fluorescent radiation for individual, and possibly especially sensitive, alloy elements. Traces of such elements are usually present even in very pure grades of aluminium. These considerations are of special interest because in some cases it has hitherto been necessary to use very complex apparatus and methods for the accurate measurement of the thicknesses of anodic films. A further point is that one of the most accurate methods of measurement[6] can be used only for colourless anodic films, whereas the method here considered seems to be suitable also for coloured films when the dyes used are organic substances of low concentrations.

Special Properties of Aluminium Alloys with High Silicon Contents

Calibration curves for spectrochemical analysis have been published[2] for commercial purity aluminium and aluminium alloys; the curves are approximately linear. For aluminium alloys containing silicon, curves are given up to about 11% silicon content. Among hypereutectic aluminium silicon alloys, certain groups with silicon contents of approximately 17% and 23% are of technical interest.[7] From the theory of X-ray spectrography, calibration curves can be expected to be approximately rectilinear, and the "straight calibration curve" should, therefore, be found with the same gradient in the hypereutectic region. However, Fig. 2 shows a sharp bend in the curve at the eutectic point, probably attributable to the different radiation and absorption properties in the hypereutectic region, since primary silicon crystals occur on the surface of the metal specimens. These crystals are not covered by an oxide film which absorbs the fluorescence. When the silicon crystals are embedded away from the surface and covered by aluminium or aluminium solid solution and aluminium oxide, the magnitude of fluorescent radiation depends on the properties of these covering layers. The fluorescent radiation from silicon atoms in the solid solution must pass through the surface oxide film, and will have a lower intensity compared with the radiation from primary precipitated silicon. Moreover, it is seen from other considerations that the absorption is lower in the primary silicon crystals than in the aluminium lattice or the aluminium solid solution, and silicon crystals lying just below the surface film will therefore produce stronger fluorescence than adjacent types of crystal. The intensity of fluorescence is therefore higher when primary silicon is precipitated, compared with that from a hypo-eutectic region, especially when the number of crystals per unit volume examined is increased as a result of the higher silicon content of the alloy.

The region about the eutectic point in the binary system is of particular interest, because in theory this point remains unchanged, but in the presence of other alloying elements, it shifts within specifiable limits due to the formation of solid solutions. It is therefore quite possible for the lower part of the calibration curve with the flatter slope, which applies to lower silicon contents, to extend in the same direction up to the silicon contents which lie above the theoretical eutectic point of the binary system. Since in aluminium-silicon alloys the eutectic point can also be displaced up to approximately 13%[8] by modification treatments, the method of measurement involves, in this region, the additional source of error which cannot be eliminated without a metallurgical investigation, where the individual structure condition

and the degree of primary crystallisation can be determined.

Determination of the Modified Structure in Aluminium Alloys

The considerations given above suggest that definite information can be obtained by X-ray fluorescence analysis on the modified condition in aluminium alloys; we shall here confine ourselves to structures found in aluminium-silicon alloys. Published work[8,9] on the problem of the modification of aluminium-silicon alloys shows that the real reason for the modification and the extent to which the structure can be influenced by the various processes are not yet sufficiently known. If the alloy composition is known precisely—and this can be determined with sufficient accuracy by a wet chemical process, among others—it must be possible to find a definition for the degree of modification. The calibration can be carried out in families of curves for the different silicon contents, depending on the degree of modification which is to be determined micrographically. Further investigations are necessary to help to explain the nature of the modified condition of aluminium-silicon alloys, and it is possible that the method may be extended and the information be useful for other alloys.

REFERENCES

1 Paper read by Pfundt, H., Bonn, at the General Meeting of the Gesellschaft Deutscher Metallhütten- und Bergleute on 11th September, 1959, at Lindau.
2 Pfundt, H., *Z. Erzbergbau und Metallhüttenw.*, 1960, **13**, 110.
3 Technische Akademie Esslingen/Neckar, February, 1960, and others.
4 Fa. Röntgenwerk C. H. F. Müller AG/Philips, Hamburg; Fa. Siemens and Halske AG, Wernerwerk für Messtechnik, Karlsruhe.
5 Schenk, M., "Werkstoff Aluminium und seine anodische Oxydation" (Aluminium and its Anodising). 1948, Francke, A. AG Verlag Bern, pp. 573 and 574.
6 Light section method according to Schmaltz G.
7 "Aluminiumtaschenbuch," 11th Edition, 1955, Düsseldorf, p. 60 (on piston alloys).
8 Spengler, H., *Metall.*, 1955, **9**, 181 and in particular 183.
9 Görtler, G., *Z. Metallkde*, 1953, **44**, 503; Löhberg, K., *Giesserei*, 1957, **44**, 89.

New Ferro-Chrome Smelter for S. Rhodesia

A NEW smelter is to be erected in Que Que, S. Rhodesia, to produce initially some 12,000 tons per annum of high-carbon ferrochrome from local chromite ores. The smelter will be rated at over 7,500 kVA., using Kariba power for smelting about 25,000 tons per annum of chromite concentrates.

The company responsible for this project is Windsor Ferroalloys (Pte.), Ltd., with John Miles & Partners as consulting engineers. The company has taken over Windsor Chrome Mines, which have operated for some years in this area. Work on the erection is to commence immediately. The head of the new company is Mr. L. H. Timmins, who for many years has had a controlling interest in the Windsor Mines; the other directors are Mr. J. A. Timmins and Mr. J. J. Shannon, all of Montreal, Canada. The new company has an authorised capital of £150,000. Over £300,000 has already been invested in Rhodesia by Mr. Timmins and his Canadian associates; the smelter operation will create an additional capital requirement of two-and-a-half times that figure.

The assets of the new company include approximately 290 blocks of claims located on the great dyke between the Sebakwe River on the South and the Ngesi River on the North. The Umniati River divides the property in half, and it is upon the banks of this river that the Windsor mine and its plant, which includes a concentrator, are located, approximately 45 miles by a good highway from Que Que.

Continuous Casting Plant for T.I.

FOLLOWING inspection of existing continuous casting plants in England and on the Continent, Tube Investments, Ltd., London, have decided to install a Concast continuous casting machine at their Round Oak Steel Works, Brierley Hill, Staffs. The machine will be the pilot plant for experimental and research work for the whole T.I. group. It is to be built and erected by Distington Engineering Co., Ltd., Workington, a subsidiary of The United Steel Cos., Ltd., and associate of Concast A.G., Zürich, in the field of continuous casting.

The Round Oak plant will be a single-strand unit designed to cast killed carbon steels into 2 in. to 6 in. sections. Liquid steel produced in an electric arc furnace will be poured from a five-ton ladle into a tundish feeding direct into a water-cooled copper mould. After leaving the spray cooling chamber and withdrawal rolls, the solidified billet will be cut during its descent and then discharged vertically on to a tilting table, which will tilt the billet on to a horizontal roller path.

Concast continuous casting machines are at present being built by Distington for Appleby-Frodingham Steel Co., Scunthorpe; Richard Thomas and Baldwins, Ltd., Panteg; Shelton Iron and Steel, Ltd., Stoke-on-Trent; Canara Workshops, Ltd., Mangalore, India; and K-M Steel Products, Ltd., Richmond, New South Wales, Australia.

Honeywell Automation Order for R. T. B. Spencer Works

HONEYWELL CONTROLS, LTD., have received orders for process control instrumentation totalling £¾ million for use at the new integrated Spencer steelworks of Richard Thomas and Baldwins, Ltd., near Newport, Mon. Much of the installation will be done by Honeywell. Temperature, flow, pressure and oxygen analysing equipment will be supplied for reheating and heat treatment furnaces being installed by Priest Furnaces, Ltd., Stein and Atkinson, Ltd., and Incandescent Heat Co., Ltd. Instrumentation is also being installed by Honeywell for lime kilns, ore dryers, pickle line, acid recovery and other plant mainly on direct order from R.T.B.

Aluminium Ltd.'s German Expansion

THE acquisition by its fully-owned subsidiary, Aluminiumwerke Nürnberg GmbH, of a modern aluminium foundry at Uphusen, near Bremen, has doubled the foundry capacity of Aluminium, Ltd., in Germany to nearly 10,000 tons a year. In addition the construction of the company's expanded sheet and strip rolling facilities at Göttingen is proceeding on schedule, and when completed this plant will treble its aluminium sheet rolling capacity in Germany to about 25,000 tons, thereby providing an additional outlet for Alcan primary metal from Canada. The total new plant investment in Germany under Aluminium Ltd.'s present programme amounts to about $12 million, some of local origin.

Sebastian De Ferranti

A Pioneer in the Electrical Engineering Field

By Eric N. Simons

An early interest in engines marked Sebastian de Ferranti, the son of artistic parents, as a future engineer, but it was in the then new field of electrical engineering that he was to make his name known throughout the world. His mechanical bent led to his entering the electrical field via the lighting generator, but his subsequent interests covered a wide range of electrical developments in a career which stretched from the early dynamo to the radio age.

SEBASTIAN ZIANI DE FERRANTI was unquestionably a man of extraordinary genius, whose remarkable abilities manifested themselves at an early age. Born in Liverpool on 9th April, 1864, he was the son of César de Ferranti, an artistic photographer of the Lancashire city, and Juliana Scott, an accomplished musician. It is clear that both the Ferrantis had artistic ability and temperament, developed moreover by their training, but their young son speedily revealed himself as the possessor of a character entirely different. Right from childhood he displayed great interest in engines of all kinds, and the family have in their possession a scrap-book which is filled with cuttings of engines, from locomotives to steam turbines, to fire engines and pumps, and from ships' engines to industrial engines of various types. These were cut out of a number of journals and newspapers that came into the house, and pasted in the scrap-book.

Going out into Liverpool streets with his nurse, Ferranti's favourite route took in Lime Street station, and there, one day, he drew a locomotive. The sketch still exists, and Sir Henry Fowler, chief mechanical engineer of the London, Midland and Scottish Railway, described it as " wonderful " when he saw it.

At the age of eight, young Ferranti was taken to Belgium so that he might learn to speak French, but he was homesick and unhappy, and speedily returned to this country, where he was sent away to school—St. Stanislas's School at Hampstead, London. By the time he was twelve years old, he had already narrowed down his interests to the one absorbing focal point—engines. He wrote to his sister : " Please ask Vincent if he can get me a book on " Compound " steam illustrated so that I can see about the condenser, because I want to see about it for a particular reason I have thought of. I also thought of it in 1874, 1875 and last Xmas holidays . . ."

At the age of thirteen, the boy left the school in Hampstead, which was kept by a French lady, and entered the Roman Catholic College of St. Augustine's at Ramsgate in Kent. When he walked into this school he had in his pocket Ganot and Pepper's " Book of Science," which was his principal companion when lessons were over. As a student he is said to have been conscientious, but to show little enthusiasm for conventional subjects. In between the construing of Latin he was turning his mind to such mundane and mechanical items as wheels, pistons, valves and pipes.

During this period he wrote to another sister : " I have just thought of an instrument for the whale fishery. You know when you run along with an umbrella one way the wind catches in it and makes great resistance, wherefor if you push it along the opposite way it shuts up (if it is not fastened by the spring) and gives no resistance to the wind, and can be shut up into very small space. Now if these were made in metal or very strong steel on a larger scale and attached to a whale line when it went along, these things would retard its progress a great deal, but when the line is pulled in it would shut up and offer little or no resistance. (N.B.—I thought of this during writing class yesterday)." (This principle applied to the parachute is used today for aircraft.)

An Unusual School

Even in those days there were schoolmasters with sympathy and intelligence. It was plain to them that they had in their care a boy of extraordinary character. Instead of harshly compelling him to grind away at subjects for which he manifested no special inclination, they had the generosity to allot him a room in which, all alone, he could work on the practical problems that interested him, and so make full use of his budding genius. On the authority of Abbot Egan, headmaster of the College, it is stated that during the two years he spent at St. Augustine's, he made small inventions and discoveries too numerous to mention. The freedom from normal routine and the valuable use he made of his time laid the foundations, it is certain, of his brilliant success in later life.

When he was fourteen, he occupied himself with the invention of a novel magnetic machine, which was to be the parent of the famous Ferranti alternator patented for the first time in 1882. The construction of this machine filled his mind almost to the exclusion of everything else. In April, 1879, he wrote to his parents an account of how he had been into the town to buy some steel for the magnets he required, and had taken it to be cut into the shape needed. At the end of a month he was still waiting for them (at least it can be said that magnets are produced more quickly today).

The new magnetic machine had, in the end, to be abandoned, and now there began for the youth a period of difficulty. Although his labours had been tolerantly and sympathetically observed at college, his father was beginning to be alarmed and disconcerted by his son's obsession with the invention of machines of one sort or another. Not unnaturally, he began to kick against the demands upon his income made by the boy's continual requests for small sums with which to pay for the materials he required in the pursuit of his experiments.

This might have mattered less had it not been obvious that in spelling and handwriting Sebastian did not come up to his father's standards. There are letters extant that reveal some resentment on both sides. César de Ferranti insisted that his son must pass the London Matriculation examination, and began to bring pressure to bear to ensure this.

Sebastian did not dogmatically oppose this plan, but he was far from being enthusiastic, and it is said that the school authorities themselves saw something wrong in a system that compelled a boy, brilliant in a whole range of specialised subjects, to grind away at a mass of unrelated facts of an entirely different order, likely to be useless to him in later years, solely so that he might pass through the narrow gateway of matriculation to a conventional "career." It is worthy of note that the youth followed up his practical studies, even to the extent of locating at a neighbouring monastery school at Canterbury a lathe that he was allowed to work.

He was still at the college in 1880, and then he met with an accident that threatened to end his scientific career. While joining two pieces of carbon together, he was struck by a spurt of hot lead, which affected his eye. The result was a stay of six weeks in a dark room, and a ban on work in his little sanctum. Before the year was out, however, he was back again working away at his machines.

In 1881 he at last left the college, and now all question of an artistic career was settled and dismissed. He had made up his mind to become a manufacturing engineer, but unfortunately, his father had neither the capital to set him up in business for himself, nor the income that would suffice to pay the fees for his further training and an apprenticeship. If Sebastian was to succeed, he must do so by his own brains and unaided efforts. The young man had had no commercial training, and knew nothing of finance or commerce, which in any event were alien to his type of mind. The only solution was for him to get himself a job, which was not easy ; but eventually, Messrs. Siemens Bros., not being gifted with second sight, took him on at his own request. He had managed to sell a small dynamo he had constructed, and the firm in question employed him at their Charlton works. There he gained a great deal of useful experience, but was not able to carry out much research on his own account. While with Siemens he superintended the installation of electric light in different parts of the kingdom, and in September, 1881, took charge of the electric lighting arrangements at an industrial exhibition in Wolverhampton.

An Important Meeting

While he was at Wolverhampton an event occurred that transformed Ferranti's entire existence. He met Alfred Thompson, an engineer, through whose good offices he was introduced to a lawyer who happened to be extremely interested in electrical science—Francis Ince. Ince recognized the young man's genius, insisted on setting him up in business for himself, and undertook to provide the necessary capital. Such benevolence is all too rare in the history of invention.

The company, under the name of Ferranti, Thompson & Ince, Ltd., was formed in 1882, Ferranti himself being appointed engineer to the new company. His invention of the zig-zag armature for dynamos was taken in hand and created a sensation in the electrical world, since it gave five times as much light as other machines of the same dimensions.

In 1886, Ferranti was called in to act as engineer to the Grosvenor Gallery Co., and laid down the principle that power should be generated on a large scale, outside the great centres supplied, where land was cheap, water and power available. The owners of the Grosvenor Gallery system of lighting decided to embark upon a far larger enterprise than originally contemplated. The difficulty lay in safely handling the high pressure current Ferranti advocated. He solved this by using concentric mains, with the outer conductor connected to the earth, taking the responsibility of disregarding Board of Trade regulations. The Grosvenor Gallery works merged with the London Electric Supply Corporation, whose directors believed absolutely in Ferranti and his ideas. Their success at Deptford forms a chapter in electrical history. In 1889 Thomas Alva Edison visited the Deptford works, criticised the Ferranti system, and the two men agreed to disagree.

Business Difficulties

On 24th April, 1888, Ferranti married Gertrude Ince, second daughter of Francis Ince. In 1892, he gave up his post as engineer-in-chief at Deptford, having determined to build up his own business as a manufacturing engineer. Conditions in 1890 and 1891 were difficult ; the Deptford company had failed financially, and it was difficult to find the cash to start a new establishment. Cooke's, the printer's, of Leeds—still in existence—were consulted, and in 1891 Ferranti went to Sheffield to see the Electric Light and Telephone Co. there. After this visit he wrote : "After talking to the manager for about four hours solidly (most of which had to be done by me, being technical) we came away with an order for about £1,000-worth of cable, just something for the new Company to start with. He is not satisfied with the Brush machinery (dynamos and engines) and I am pretty sure that he will come to us, as he says our system is better worked out and more finished. He will have to decide to buy more dynamos in about three weeks, before which time I shall see him again. Although it took a day, I thought it worth going, as it means business for us and will make the directors of the Wire Company easier to deal with on Friday."

Business improved. The true turn of affairs came with the lighting of Portsmouth, who awarded the contract to Ferranti's. After this station was opened, Ferranti's reputation grew both here and abroad, and he put down plant in France, Germany and Switzerland. In Edinburgh he delivered a lecture on the Ferranti meter, and the Prize Committee of the Royal Scottish Society of Arts awarded him the Keith prize of £30 for this paper.

It is worthy of record that the machinery Ferranti proposed to the Committee that decided what electrical system should be adopted for Portsmouth differed from any other. The three principal departures from precedent were that the dynamos were mounted on the fly-wheel of the engine and ran at a low speed (97 r.p.m.) ; the arc lighting was achieved by continuous current from the alternating current, using rectifiers ; and the current was distributed by automatic changeover converters, which enabled extremely high efficiency to be obtained. These ideas had never been put into practice, yet the Committee considered the system mechanically perfect and determined to trust their own judgment.

Ill several times in 1895 and operated upon for appendicitis in 1896, he decided to build a new works for his growing business, and in May 1896 built at Hollinswood, Oldham. Finance, as we have seen, was not the inventor's strong point, and things did not go well in this respect. The company had to be wound up in February 1894, but was reconstructed and put on a sound footing.

In 1905 Ferranti went to Sheffield to experiment at the works of Vickers, Ltd., with a turbine he had invented. He had been living in Hampstead for seven years, but now, to be nearer his works, the inventor moved to Grindleford, a country hotel, "The Commercial," kept by Mrs. Outram, being his headquarters. Ferranti's mother died in 1906, and in 1907 the Ferrantis moved into their own house, "Ingleside," at Grindleford. Two of Ferranti's sons, Basil and Vincent, matriculated at the University of Sheffield.

In 1910, Ferranti was elected President of the Institution of Electrical Engineers. He visited the United States, and in 1912 the degree of Doctor of Science was conferred upon him by the University of Manchester. In 1913, he bought a beautiful stone-built house at Baslow, not far from Chatsworth, near Sheffield, and the family moved to this new address.

Of the two sons, Basil, the elder, was killed in World War I, but Vincent, after service in Gallipoli and Bulgaria, came home safely in November 1918. In this year, Ferranti, greatly shaken by the loss of his son, was busy working on the internal combustion engine, and particularly on the gas engine. These experiments were not highly successful. Later, he carried out a series of experiments for the Air Ministry in an endeavour to obtain a high speed engine using heavy oils instead of petrol. Later in this same year we find him experimenting with new designs of sparking plugs for aircraft engines.

Faraday Medallist

In March 1921 he began work on yet another new invention, designed to prevent punctures in automobile tyres, and in the days when tyres were much smaller than those of modern type, this invention proved to be most effective, but in the end he gave it up because it became unnecessary as tyres and roads improved. In April 1924 he was awarded the Faraday Medal by the Institution of Electrical Engineers, and about this period he had already begun to turn his attention to radio, carrying out a number of experiments. In this year he made yet another visit to the States, where he had the privilege of meeting the celebrated Henry Ford : he also visited Canada.

In 1927, he was elected to the Royal Society, an honour he greatly valued, and during this year he delivered the Faraday lecture on "Electricity in the Service of Man."

In 1929, the illness that had been troubling him for some time came to its climax, and during a holiday in Switzerland, it became necessary for him to undergo an operation. Thirteen days after entering a hospital he died, as the result of coronary thrombosis. He was then 65. So ended a life devoted to the development of inventions of enormous importance to human welfare and comfort. It was a life not sensational, perhaps, either in its beginnings or in its climax, but it was one full of persistent and untiring effort, marked by flashes of genius at every end and turn.

We may perhaps end this account on a lighter note. In 1894, the inventor was the guest for dinner in Edinburgh of Dr. Taylor. Another guest was Bruce Peebles, founder of the well-known Scottish electrical firm of that name. Peebles replied to Taylor's invitation in verse, and some of the lines read as follows :—

'Had you asked me to meet with a very dear friend,
Say a cousin or uncle or auntie,
The pleasure I'd have would not equal by half
What t'will be when I meet with Ferranti.

'We shall drink to his health, and rejoice that the land
Which can give us such poets as Dante,
Can also alternately change her bit plan
And yield such a man as Ferranti.'

Asked for a copy of the verses, he complied, adding a postscript :—

'You asked me for a copy of the above—
I comply with your wish, and now that I've met
Both Mr. and Mrs. Ferranti,
He pleasant and frank, a man we all liked,
She beautiful, charming and canty.

'We all wish them well, may they flourish and thrive,
And their goods and their gear ne'er be scanty ;
So I thank you, good friend, for great pleasure I had
Meeting Mr. and Mrs. Ferranti.'

Readers who wish to know more about this remarkable man will find all they require in "The Life and Letters of Sebastian Ziani de Ferranti," by Gertrude Ferranti and Richard Ince, 1934.

Twice as Fast with High-speed Nozzles

Production time in the fabrication of stator cases has been more than halved at General Utilities, Ltd., Poynton, with the use of British Oxygen's high-speed nozzles on the 84-in. Bison cutting machine. Fifteen sets of six stator cases have been made for Lancashire Dynamo & Crypto, Ltd., who are building generators for installation in Polish power stations : two out of each set have scalloped edges. Individual cases were 7 ft. by 6 ft. in area and $\frac{1}{2}$ in., $\frac{3}{4}$ in. or $1\frac{1}{8}$ in. in thickness. General Utilities' job was to cut the internal profile on each—60 in. in diameter on the plain cases and 60 in. maximum diameter on the others—to shape the outside of the cases and to cut out ten small holes in each. Fitted with standard nozzles, the Bison took about $3\frac{1}{2}$ hours to cut one of the scalloped cases. A British Oxygen specialist suggested high-speed nozzles, which use acetylene as the fuel gas. Cutting time per case was reduced to under $1\frac{1}{2}$ hours and the quality of cut was maintained.

Semiconductor Conference

The Institute of Physics and the Physical Society, on behalf of the International Union of Pure and Applied Physics and the British National Committee for Physics, is arranging an international conference on "The Physics of Semiconductors," which will be held at the University of Exeter from 16th-20th July, 1962. The conference is planned to follow the previous sequence of conferences on the physics of semiconductors, which were held in Reading in 1950, Amsterdam in 1954, Garmisch in 1956, Rochester in 1958 and Prague in 1960. Accommodation will be provided in halls of residence at the university. Provisional programmes and application forms may be obtained from the Administration Assistant, The Institute of Physics and the Physical Society, 47 Belgrave Square, London, S.W.1.

Anodised and Lacquered Aluminium Strip

Its Manufacture and Use for Double-Drawn Cans

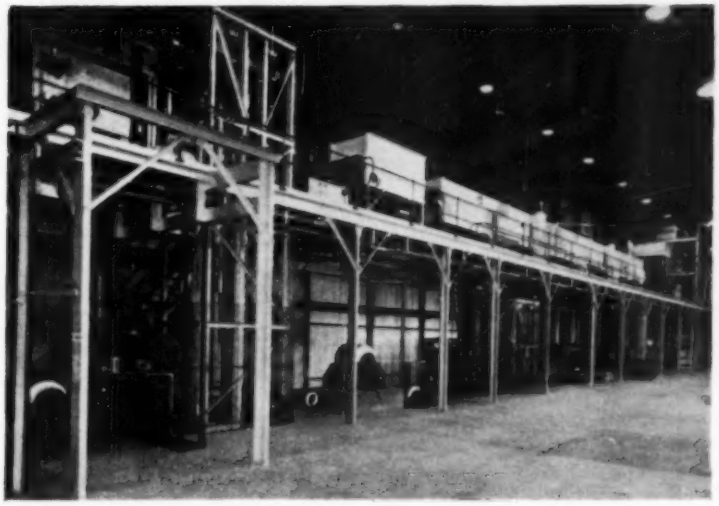


Fig. 1.—General view of line looking from the coiler towards the drying tower.

IT is estimated that the amount of aluminium used for making cans in Europe (including the United Kingdom) in 1961 will be over 20,000 tons, representing a 20% increase on the 1960 figures, which themselves were 20% higher than the 1959 figures. In the U.S.A., the figures for the first quarter of 1961, at 8,987 short tons, were 83% higher than those for the corresponding quarter in 1960 and 62% higher than the figures for the last quarter of 1960. In the United States the emphasis is on the built-up three-piece 1 qt. oil cans and the 6 oz. frozen fruit juice cans. In Europe, on the other hand, the impact-extruded cylindrical tall can is the most widely used, but there is a large and important market for shallow-drawn cans for fish and crustaceans.

These shallow-drawn cans are produced from pre-lacquered strip in a single draw, and more than a million cans are so produced each year. The growth in their use has been stunted by a lack of plant capacity for the continuous anodising and lacquering of coiled aluminium strip. The only plant in existence in the world for producing such material was located in Norway and had an output limited to 3,000 tons per annum. This figure has now been increased to 6,000 tons and the commissioning of the new line at Alcan Industries' plant at Rogerstone will mean that in 1962 there will be available 10,000 tons capacity. Other European plants coming into production will increase the figure to 15,000 tons by 1963.

Rogerstone Production Line

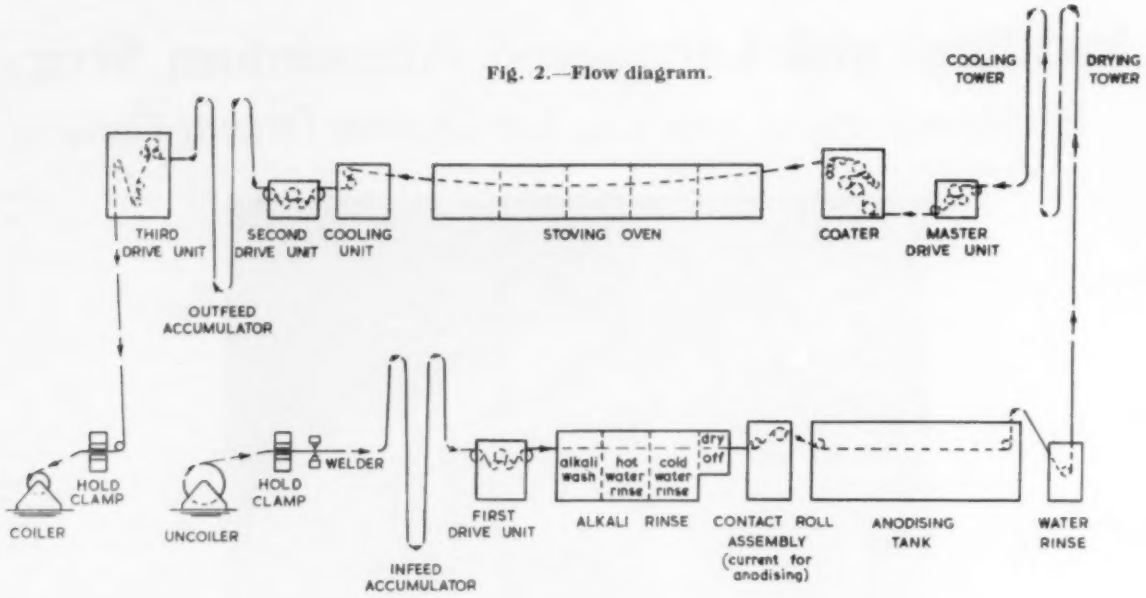
The continuous anodising and lacquering line at the Rogerstone works of Alcan Industries, Ltd., has been developed for the production of pre-lacquered aluminium strip for use in the canning industry. Basically the line, a general view of which is shown in Fig. 1, comprises a series of units in which the aluminium strip is successively washed, anodised, coated with lacquer, and stoved. The material, known as "Anolac," will be available in Noral M57S alloy in all tempers, and in Noral 2S and 3S alloys in all tempers except fully annealed. The anodising process ensures the maximum adhesion of the lacquer and enables the material to be subjected to most types of forming without breakdown of the lacquer coating. The line will initially be used for coating material up to 26 in. wide and from 0·008 in. to 0·018 in. thick, depending on the alloy and temper of the strip. A wide range of colours and types of stoving lacquer can be applied.

Feeding the Strip

The various units comprising the line are shown diagramatically in Fig. 2, which shows the progress of the strip from the uncoiler to the final coiler. The line is prepared for operation by placing a coil of aluminium strip on the uncoiler and threading it through all the units in the line to the coiler at the opposite end. The taking up of fresh coils is carried out without stopping the line. When the end of a coil is reached on the uncoiler, the hold clamp is operated to keep the end of the strip stationary while a new coil is fitted. The ends of the old and new strips are then joined together by a spot welder, after which the hold clamp is released and the new strip moves into the line through the infeed accumulator.

While the hold clamp has been keeping the ends of the strips stationary, the line has continued to operate with the remainder of the old strip still moving. This is

Fig. 2.—Flow diagram.



accomplished by the action of the infeed accumulator, which is a system of rollers normally accommodating 160 ft. of material between the welder and the first drive unit. The welding operation must, of course, be completed before the strip within the accumulator is exhausted, but, if for some reason this is not accomplished, an automatic switch stops the line and cuts off the current in the anodising tank.

The speed and tension of the strip through the line are maintained by four drive units which are connected, through eddy-current couplings, to constant-speed motors, and are electronically inter-connected. The electronic circuit has a time-control to prevent acceleration and deceleration of the strip beyond fixed limits, and the tension of each section between drives can be maintained at any constant chosen value.

Anodising

All traces of oil and dirt are removed in the alkali-rinse unit, which has four stages, consisting of an alkali wash, a cold water rinse, a hot water rinse, and an air drier. The contact roll assembly provides the electrical contact for the strip while in the anodising tank that it is about to enter, and incorporates a scraper blade to keep the contact roll clean and thus ensure efficient electrical contact. It also incorporates a drive having a constant torque feature to prevent relative motion between roller and strip, with consequent sparking.

The anodising tank (Fig. 3) has a rating of 4,000A. at 12–24V. with a designed anodic film thickness of 0·3 micron at a line speed of 100 ft./min. (one micron = 0·00004 in.). The electrolyte is 15% sulphuric acid and the enclosed tank is of rubber-lined mild steel and has fume extraction equipment of the lip type. Pre-heating equipment is provided and cooling coils control the temperature of the electrolyte during anodising. At the end of the tank a squeegee roll removes surplus acid from the surface of the strip. All traces of electrolyte are removed from the strip in the water rinse before it enters the drying tower, where it is dried with hot air from a 100kW. thermostatically-controlled electric heater and then cooled with cold air. From the cooling tower the strip passes through the master drive unit, which controls the speed of the strip throughout the line and is interconnected with the other subsidiary drive units as already mentioned.

Coating

In the coater (Fig. 4) the lacquer is applied through two sets of rolls, one set for each side of the strip. Each set is of the 3-roll reversible type in which the rolls are driven by a constant-speed electric motor through a variable speed hydraulic gear box, the application roll, if required, travelling in the reverse direction to the strip. The thickness of the coating is metered by the gaps between the rolls, which are adjustable relative to each other. Control of the coating thickness is by weighing a sample of coated strip of certain size. If required, the metal can be coated on one side only, or both sides can be coated with the same or different lacquers or coatings.

From the coater, the strip passes into the stoving oven, which is of the direct gas-fired type with five zones to ensure controlled heat distribution. The oven, which can operate at temperatures up to 370° C. and is fitted with the usual flame-failure devices, is 70 ft. long; the strip is unsupported while passing through it. In the cooling unit the strip is first cooled by cold air and then by passing it over two water-cooled rolls.

Coiling the Coated Strip

The second of the subsidiary drive units, which is similar in construction and function to the first, takes the strip emerging from the cooling unit and delivers it to the outfeed accumulator. This is similar to the infeed accumulator, but normally runs empty. It comes into operation, storing up to 160 ft. of strip when the coiler is full and the completed coil is being removed.

The last of the subsidiary drive units differs from the other two in that it incorporates a tension control device for the coiler. The hold clamp is similar to the one at the beginning of the line and comes into operation when the coiler is full. While the metal is held in the clamp it is severed by the guillotine and a new coil is started. The clamp is then released and the strip, which has been held in the outfeed accumulator, begins to run again.

Contractors

The line was constructed under the supervision of Alcan Industries' general engineering department, the main suppliers of equipment being as follows :—

Electrochemical Engineering Co., Ltd.	Alkali rinse, contact roll (excluding drive, anodising tank, water rinse, drying tower.
Loewy Engineering Co., Ltd.	Coiler
Sciaky Electric Welding Machines, Ltd.	Spot welder.
Stordy Engineering, Ltd.	Infeed accumulator, all drive units, coater, stoving oven, cooling unit, outfeed accumulator.

Double-drawn Cans from Pre-lacquered Strip

Although the aluminium food can has the advantages of ease of opening, absence of a side-seam because it can be drawn or impact-extruded, freedom from rust, and reduced freight charges where cans have to be transported empty, economics have so far prevented its wide-scale adoption in this country, where tinplate is comparatively cheap. One of the main elements of the higher cost has been the spray lacquering or anodising operation carried out after the can has been formed. Spray lacquering must be preceded by thorough degreasing, and expensive equipment is needed for applying and stoving the lacquer, while anodising is normally a a batch process involving high labour costs.

Development of the Double-Drawn Aluminium Can

To overcome these disadvantages Aluminium Laboratories, Ltd., Banbury, have been developing a method of producing double-drawn aluminium cans from aluminium strip that has already been lacquered. Material of this type has been in use for several years in Scandinavia and Portugal for the production of shallow-drawn fish cans, but no previous experience had been gained with deep-drawn cylindrical cans. A prototype canning line has therefore, been developed by Aluminium Laboratories, Ltd. for the production of 211 × 205 (6 oz.) cans from pre-lacquered coils of aluminium strip. The cans are cylindrical and have a length/diameter ratio of approximately 1 : 1. It was decided that the cans would have to be able to withstand processing without the use of super-pressure autoclaves, which are normally required when making shallow-drawn fish cans, and it would, therefore, be necessary to produce the cans from an aluminium alloy which combined adequate strength with suitable drawing characteristics. Consequently, the material chosen was Noral M57S$\frac{1}{2}$H alloy (B.S. 1470 : NS4$\frac{1}{2}$H), with a thickness of 0·012 in., a material already in wide use for other types of container. The production of cans from pre-lacquered material depends, of course, on the lacquer having adhesion properties that will enable it to withstand the forming operations. Previous work with shallow-drawn fish cans had shown that satisfactory lacquer adhesion could be obtained by anodising the material before lacquering, and Alcan Industries, Ltd., have installed equipment to produce a suitable material, " Anolac," described above.

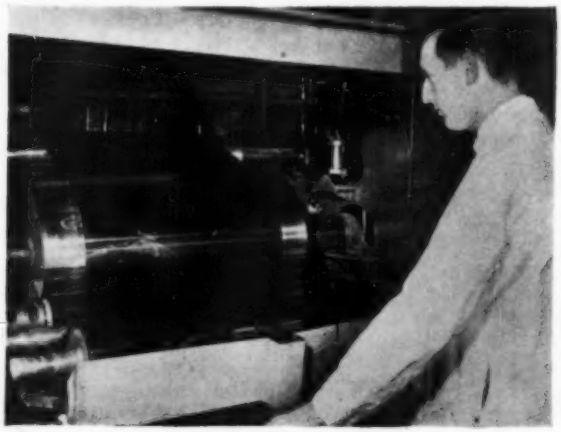


Fig. 4.—The coating unit

Fig. 3.—The anodising tank.

The Double-drawn Canning Line

The canning line at Aluminium Laboratories, Ltd., a general view of which is shown in Fig. 5, consists of two 60-ton mechanical presses, operating at 90 strokes per minute, the two presses being linked by a conveyor belt. In the first press, shown in Fig. 6 a circle is blanked from 6 in. wide " Anolac " strip and drawn into a cup, the reduction at this stage being 44% (see Fig. 7). The cup is then transferred on the conveyor belt (Fig. 8) to the second press, shown on the left of Fig. 5, which draws the cup to its final size with a 24% reduction, and embosses, flanges and trims it, all in one operation. The completed can, shown on the right in Fig. 7, is ejected from the press and the " shred " is separated by means of

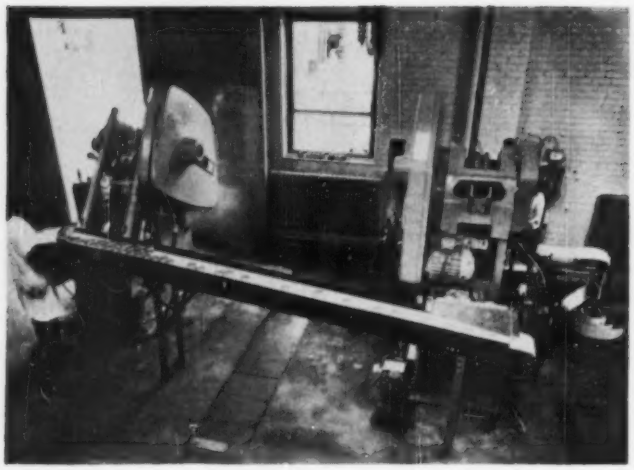


Fig. 5.—General view of the can making line showing presses and conveyor belt.

a grid over which the cans pass, but through which the shred can fall.

The tools incorporated in the presses incorporate a number of novel features, but the presses and much of the auxiliary equipment are standard commercial units. The cost of the line, excluding facilities for making and lining lids, is about £7,000 : the line requires the periodic attention of a tool fitter and the full-time services of a press operator and two non-skilled helpers.

Extensive packing tests at Aluminium Laboratories and in canning factories have shown that the cans can be used with a wide-range of low-acid foods (*p*H range 5–7) such as beans in tomato sauce, macedoine vegetables and a number of meat products.

Costs

The use of pre-lacquered strip eliminates the operations of degreasing and lacquering after forming, and results in a cheaper aluminium can than is possible by other methods. An analysis of the comparative costs of the two methods shows that the cost of anodising and lacquering the strip prior to making it into cans is approximately one-third of that of degreasing and spray lacquering the cans made from plain material. These figures are based on the manufacture of a 6 oz. can having a diameter of $2\frac{11}{16}$ in. and a height of $2\frac{5}{16}$ in. and produced at a rate of 90 cans per minute. The finished cost of cans made from pre-lacquered strip is £8 3s. per 1,000, and for cans produced from plain strip, and subsequently lacquered and degreased, £9 12s. per 1,000.

In comparison, three-piece tinplate cans of this size cost about £5 11s. per 1,000. However, the pre-lacquered aluminium can has the advantage that the capital cost of the equipment is very much lower than that for a conventional body-maker line. Since the cost of the equipment for the double-drawn canning line is approximately £7,000 it would, therefore, be an attractive proposition for a canner or prospective can maker whose output would be up to 20 million cans per year.

Shelf-Life

Extensive tests have been carried out by Aluminium Laboratories, Ltd., to determine the shelf life of both single- and double-drawn cans produced from pre-

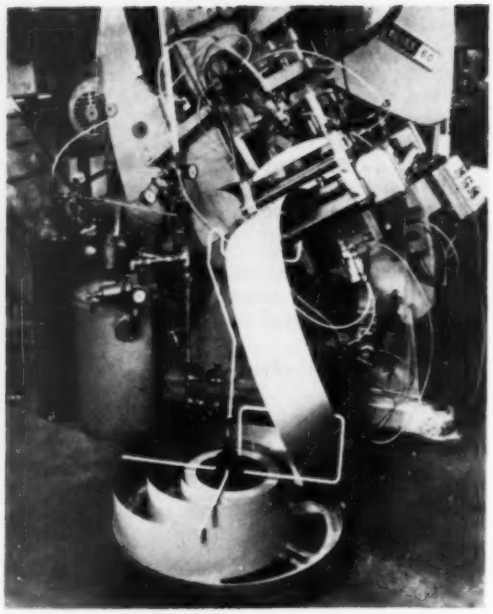


Fig. 6.—First press showing the pre-lacquered strip.

lacquered strip. The cans intended for these tests are packed under normal commercial conditions, or as near these conditions as possible, and are stored at room temperature (approximately 20° C.) or in some cases 35° C. Storage at 35° C. increases the rate of hydrogen-liberation so that shelf life at this temperature is about one-quarter of what it would be at room temperature. The results of storage tests at room temperature are considered to be the more reliable, but storage at 35° C. shortens the test time and enables predictions of shelf life to be made at a time when cans stored at room temperature still show no sign of change. In addition to storage at room temperature and 35° C., a few cans are sometimes stored at 55° C. The results from storage at this temperature may be useful in giving a rapid indication of which of two or more lacquers or alloys give the best shelf life, but the results must be used with care as changes in the nature of the product may occur at this temperature.

Results of shelf-life tests over a period of seven years show that shallow-drawn cans made from pre-lacquered

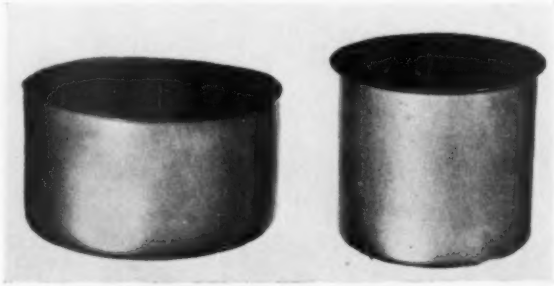


Fig. 7.—Aluminium can after first draw (left) and second draw (right).

strip can be used for a wide range of fish products with a *p*H of 5–7. A shelf life of two years or more is predicted for all but one of the packs tested and in some cases a shelf life exceeding five years has been obtained. Most of the packs in the tests concerned were made from one alloy, with one lacquer, and to one can design, and changes in any of these variables may mean that further testing is required before the material can be recommended with certainty. The results of a further series of tests show that a satisfactory shelf life can be obtained with cans produced by double-drawing in Noral M57S alloy, and with such aggressive products as beans in tomato sauce.

Other Packaging Uses of "Anolac" Strip

The material produced at the Rogerstone Works of Alcan Industries, Ltd., can be provided with any colour of lacquer to suit customers' requirements. In addition to its use on double-drawn cans the material is also suitable for other packaging applications such as crown corks, caps for pharmaceutical phials, oil can overseals, and pre-screwed caps.

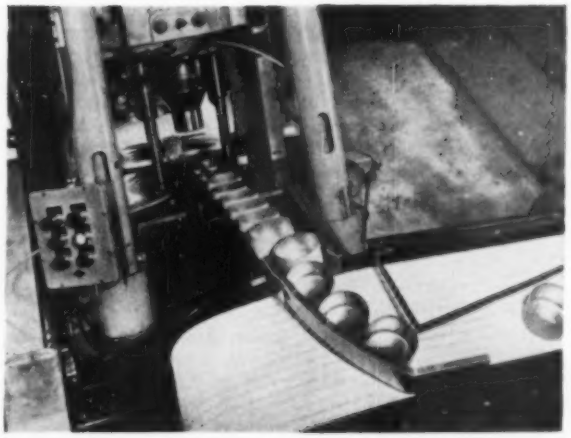


Fig. 8.—Conveyor belt showing cans entering second machine.

New and Revised British Standards

ROLLED COPPER SHEET, STRIP, AND FOIL.
(B.S.899 : 1961). PRICE 6s.

THE British Standards Institution has published a revision of B.S.899 covering rolled copper sheet, strip and foil. The original standard of 1940 and the revision of 1952 both related to material for general purposes. The new revision has extended the standard's scope to include material for electrical purposes in the form of rolled sheet and strip. This material was previously covered by B.S.1432 which has also been revised and is now restricted to strip with drawn or rolled edges. The wording and general arrangement of clauses in the new revision of B.S.899, and the tolerances specified, are in line with those included in B.S.2870, a standard soon to be published dealing with rolled copper and copper alloys in sheet, strip and foil form.

SCHEDULE OF COPPER ALLOY INGOTS AND COPPER AND COPPER ALLOY CASTINGS.
(B.S.1400 : 1961). PRICE 20s.

THIS new edition of B.S.1400 is an impressively thick publication of nearly a hundred pages which brings together general, chemical and mechanical requirements for high-conductivity copper castings and for castings and ingots in thirty-three copper alloys. The schedule was first issued in 1948 when the numerous individual British Standards for copper alloy ingots and castings were withdrawn and their requirements included in one volume.

Among the many changes in the new publication, a most useful addition is the inclusion of a colour code for each of the ingots specified. It was not possible, unfortunately, to extend this scheme to include castings.

High conductivity coppers HCC1 and HCC2 and new alloys PB4, LB4, LB5, G3, SCB4, SCB5, CMA1, CMA2, and DCB3 have now been included. Three of these arise from an extension of the range of brasses previously designated "B," and its sub-division into sand cast brasses (designated "SCB") and die cast brasses (designated "DCB"). For convenience the earlier superseded code numbers are included in the summary table. One alloy, (SB1), has been omitted.

A number of amendments have been made to the chemical compositions of the alloys, including differentiation between the limits specified for ingots and castings for certain of the elements. Mechanical properties have also been reviewed and a number of amendments made. Throughout, reference is made to "permanent set stress" instead of "proof stress" as the former is the test used with copper base casting alloys and is now defined in B.S.18, "Tensile Testing of Metals."

For the phosphor bronzes, leaded bronzes and gunmetals, properties for continuously cast material have been included. For the gunmetals and leaded gunmetals recent research on the effect of impurities has been taken into account in fixing limits only for those elements known to be harmful and likely to be present, and a total figure has not been included.

The general format of the schedule, and the wording of general and specific clauses have been brought into line as far as possible with the recommendations of PD 2436, "Memorandum on the Preparation of British Standards for Non-ferrous Metals."

COPPER FOR ELECTRICAL PURPOSES: STRIP WITH DRAWN OR ROLLED EDGES.
(B.S.1432 : 1961). PRICE 7s. 6d.

IN a new edition of this standard, its scope has been narrowed so that it embraces strip only up to 6 in. wide, and only strip whose edges or corners are finished by a process which gives closer tolerance on width than are given by slitting, shearing or other edge cutting processes. Strip over 6 in. in width, and strip or sheet of any width manufactured to wider tolerances on width, have been divorced from the standard and are now included in the revision of B.S.899.

THE SAMPLING AND ANALYSIS OF TIN AND TIN ALLOYS
(B.S.3338 : PART 10 : 1961). PRICE 3s.

THE British Standards Institution has recently published

the tenth part of a standard designed to cover all methods of sampling and analysing tin and tin alloys. The latest publication (B.S.3338 : Part 10) concerns the photometric method of determining the amount of iron in ingot tin, tin-lead solders and white metal bearing alloys. It specifies the reagents required, and recommends methods of sampling and procedure for the determination of an iron content of up to 0·03%.

Anodic Oxidation Coatings on Aluminium

(B.S.1615 : 1961). Price 7s. 6d.

In order to bring the specified properties and methods of test into line with current practice, the British Standards Institution has published a new edition of B.S.1615, "Anodic Oxidation Coatings on Aluminium." In this new edition anodic coatings are classified by their thickness only, without the former reference to the type of electrolyte. The classification has been altered to allow new grades to be systematically incorporated. The standard introduces a 1-micron grade for infra-red reflectors and, at the other end of the scale, a 35-micron grade for special architectural purposes. The thickness test by stripping has been supplemented by a micro-section method. Sealing requirements are now specified by the standard. Effectiveness of sealing is tested by a sulphur dioxide/humidity method similar to the test on chromium plated coatings for corrosion resistance specified in B.S. 1224 : in fact the same apparatus can be used.

The measurement of light reflectivity has been simplified by the use of the modified gloss head and the PRS head. The grading for heat reflectivity has been altered, but the method of test remains the same as in the 1958 edition of the standard. Requirements for fastness to light have been up-graded, and it is hoped in due course to provide still higher standards to match the fastness of present-day colour anodised aluminium.

It has not been found possible to specify an abrasion test, since no one test can be said to be of general application. However, an abrasion test which may be found useful in some cases is described along with methods of thickness assessment by eddy current instruments and a simplified method of sealing assessment (Kape method) which are recommended for control and acceptance purposes. Requirements for image clarity, corrosion resistance, leaching resistance and electrical breakdown voltage vary according to the use. Tests for such properties are described, but the extent of testing or the performance is decide by agreement in each case.

The standard offers guidance on the suitability of the aluminium for anodising, and a list of the information which should be provided with the enquiry and order is given in an appendix.

Simplified Methods for Measurement of Grit and Dust Emission from Chimneys

(B.S.3405 : 1961). Price 20s.

Of the utmost importance to works managements and local authorities is the publication of B.S.3405. This new British Standard lays down simple methods of measuring grit and dust emission from chimneys and, in the opinion of the technical committee which prepared it, should form a suitable basis for regulations under Section 7 of the Clean Air Act, 1956. Under this section, the Minister of Housing and Local Government may, in respect of specified classes of furnaces and ovens, prescribe requirements for :—

(1) making and recording of measurements from time to time of the grit and dust emitted from the furnace or oven ;

(2) making adaptations for that purpose to the chimney serving the furnace or oven ;

(3) providing and maintaining apparatus for making and recording the measurements, and,

(4) informing the local authority of the results obtained from the measurements or otherwise making these results available to them.

Since 1940 there has been a British Standard method of examining material discharged from chimneys (B.S.893, Method of Testing Dust Extraction Plant and the Emission of Solids from Chimneys of Electric Power Stations), but the Government Committee on Air Pollution, of which Sir Hugh Beaver was chairman, said in its report : "It is lengthy and complicated in practice. We think it would be of advantage to works managements and local authorities if a simpler standard method could be devised. We recommend that this work should be undertaken by the B.S.I." Hence the preparation of B.S.3405.

A note in the introduction to the standard points out that the procedure in B.S.893 should be followed when tests are being made at large installations, such as power stations, and in all cases where accuracy is important, for example, in contractual testing. B.S.3405, it is explained, lays down the rules to be observed during a test in which an accuracy of within ±25% suffices. Five different designs of apparatus which have been found suitable for carrying out the recommended procedure are described and illustrated.

Copies of these Standards may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1. (Postage will be charged extra to non-subscribers).

Cambridge Instrument in Italy

Cambridge Instrument Co., Ltd., and Instrumenti di Misura C.G.S., S.p.A., Monza (Milan, Italy), announce final agreement for the formation of a new joint company, Cambridge—C.G.S., S.p.A. The issued capital of the new company, in which each parent organisation has an equal interest, will be 3 million lire, official permission having been given for the remittance of the Cambridge contribution. The factory will be located at Casoria, near Naples, adjoining an existing production plant of Instrumenti di Misura, C.G.S.

"C.G.S." which has its origins in a company founded over 65 years ago by Camillo Olivetti, employs over 1,500 people and manufactures a wide range of electrical measuring equipment for industrial and laboratory use, including switchboard and precision indicators and recorders, instrument transformers of all types, and supply meters.

Cambridge—C.G.S. will initially manufacture instruments based on Cambridge designs, including electronic and galvanometric indicators and recorders for a wide range of applications, and galvanometric control equipment. These will, where necessary, be adapted to meet the requirements of the Italian and neighbouring markets. The distribution function will be in the hands of C.G.S. and Soc. Ing. Taragni & C., the latter having for many years acted as agents for Cambridge in Italy.

Electric Billet Heater for Austin

Two-Tunnel G.W.B. Unit for Con-Rod Production

TO replace three oil-fired furnaces, the Austin Motor Co., Ltd., have installed in their Longbridge works a G.W.B. two-tunnel induction heater. This new heater will, it is claimed, do twice the work of the three conventional type furnaces in reheating manganese-molybdenum steel billets prior to forging them into connecting rods.

Rapid Heating

Although the principle of induction heating has been established for some considerable time, it is only in recent years that the many advantages offered by such equipment have been fully realised. The heating achieved by this method is faster than by any other process. It is economic and efficient, and the compact equipment takes up a relatively small amount of floor space. The plant is clean, and cool working conditions are obtained, important factors which play a considerable part in obtaining higher production performances by its operators.

The new furnace, capable of heating up to a temperature of 1,250° C., is wholly engaged in the heating of En 16 steel billets measuring $1\frac{5}{8}$ in. square × $8\frac{5}{8}$ in. long and $1\frac{1}{4}$ in. square × $7\frac{5}{8}$ in. long, each billet making a pair of con rods. Dependent upon which size of billet is being heated, the larger weighs 6·5 lb. the smaller 4·8 lb. (approx.), they can be discharged from each coil at the rate of one every 13–14 seconds. Pneumatic interlocked pushers operate on a preset time cycle and load one billet into each of the two coils alternately to give a workpiece discharge of one billet per 6·5–7 seconds from both coils.

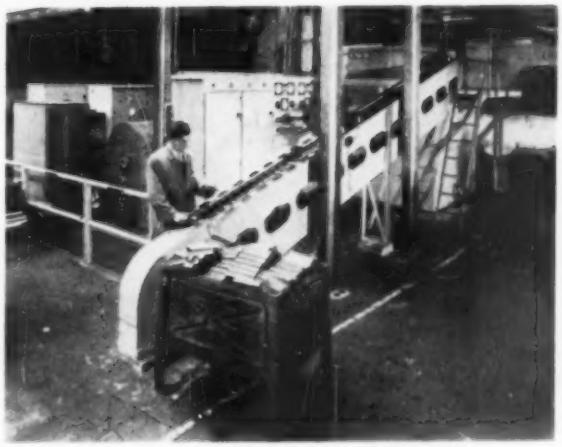
After heating to the required temperature the billets fall on to an inclined chute which deliver them to the bed of a Wilkins & Mitchell reducing roll. After three rolling operations they are hand fed into a Hasenclever forging press where they are flattened, moulded and finished. Finally, they are clipped on a Wilkins & Mitchell clipping press.

The coils, which are the hearts of the furnace, are formed from high conductivity water-cooled conductors, each coil being 58 in. long. Electrically, the billet heater is arranged as two independent units and can be run as a single-tunnel equipment if required. The control panel, and similarly the power equipments, are arranged in the form of two separate sets.

Control Panel

The panel, designed by G.W.B.'s furnace division and built by the company's control gear division, houses the mechanical handling control equipment, the alternator regulators, and the automatic power factor control equipment for each of the twin coils. Automatic power factor correction is effected by switched capacitors mounted within the base of the furnace units, which also house the main isolating contactors and water-cooled matching transformers.

The coil units are mounted above this control panel and stand about 8 ft. from the ground. The cropped billets are loaded at floor level on to a flighted conveyor which delivers them to the coil charging position. Two 300 kW., 2,500 c./s. motor alternator sets are incorporated, each consisting of a 485 h.p. induction motor mounted on a common bedplate with one alternator.



View of the electric billet heater showing cropped billets being loaded on to the flighted conveyor which delivers them to the coil charging position.

W. H. A. Robertson's £1·5 m. Extensions

THE £1,500,000 extension to the works of W. H. A. Robertson & Co., Ltd., of Bedford, a member of the Tube Investments engineering division, which was held up in June, is now being resumed, and should be completed by the end of 1962. The hold-up was due to the shortage of skilled labour and difficulties foreseen in manning the extensions, matters which have been met by a housing agreement with the Bedford Town Council. The project will include heavy machine and erection bays capable of handling weights up to 300 tons, this placing Robertsons in an advantageous position for heavy plant manufacture. W. H. A. Robertson & Co., Ltd., designs and produces rolling mills, forging machines and other engineering plant and equipment.

Kent Sheffield Office

GEORGE KENT, LTD., have opened a Sheffield office at Lloyds Bank Chambers, Earl Street, Sheffield 1, (Tel.: Sheffield 77471/2). The branch is under the supervision of Mr. H. E. Farrar, area manager, assisted by Mr. G. H. Sharp, senior sales engineer, and is able to provide technical and contracting facilities with the additional support of a district service engineer and team.

News in Brief

A MODERN combined medium section and beam mill, having a monthly production capacity of 30,000 tons, is to be installed by Lorraine Escaut S.A., at their Longwy steel works. Schloemann A.G., have been awarded the contract for engineering the complete mill and they will be supplying a large part of the rolling mill equipment.

ASSOCIATED ELECTRICAL INDUSTRIES, LTD., has been awarded a £171,000 contract for the supply and installation of cables and accessories, including cable supporting steelwork, for two 200 mW. generating sets at Kincardine "B" Power Station. The cable will be manufactured by AEI cable division at its Gravesend and Woolwich factories.

OPTOSHIELD, LTD., the manufacturers of eye protection and other safety products, are transferring all their production and development departments to more spacious accommodation at Watford, to implement their extensive new development programme. The sales department and head office remain at 146, Clerkenwell Road, London, E.C.1.

AGAINST severe international competition the British Insulated Callender's Cables group of companies have secured a £330,000 contract from the Central Electricity Board of the Federation of Malaya for the supply and installation of some 60 miles of cables—power, control and telephone—for the Cameron Highland hydro-electric scheme.

A VERTICAL type continuous casting plant for steel, built by Schloemann A.G., Düsseldorf, in association with Concast A.G., Zürich, was recently taken into commission by the Dillinger steelworks. At the present time 40 in. by 8 in. slabs are being produced: it is proposed soon to take up the production of 60 in. by 8 in. slabs.

A NEW line of hardening and tempering furnaces and ancillary plant has just been brought into commission at the Tipton, Staffordshire, factory of Firth Cleveland Steel Strip, Ltd., a member of the Firth Cleveland Group. The company will now be able to supply hardened and tempered steel strip up to a maximum of 18 in. wide and 0·096 in. thick, compared with a previous maximum of 13 in. wide and 0·080 in. thick.

THE UNITED STEEL COS.' department of operational research and cybernetics is now known as the department of operational research. Study of cybernetics will continue as part of the work of the department and its application will be an integral part of operational research.

BROWN BAYLEY STEELS, LTD., have placed a contract worth some £800,000 with The Brightside Foundry and Engineering Co., Ltd., Sheffield, for a new 32 in. blooming mill and the reconstruction of the existing 28 in. finishing mill at their Attercliffe Works.

G.E.C. (ENGINEERING), LTD., has recently received an order, valued at over £10,000 for a sealed water-quench furnace. It is for installation in the Burnley Works of the Lucas Gas Turbine Equipment, Ltd., where it will be used for the annealing and hardening of various types of high-grade steel and steel alloys employed in the aircraft industry. The rigorous requirements of this industry call for an accurate control of the furnace temperature so that the treated parts may have uniform characteristics.

THE LOEWY ENGINEERING CO., LTD., of Bournemouth, a member of the engineering division of Tube Investments, Ltd., has received an order from France valued at over £100,000 for a 1,200 tons oil-hydraulic free-forging press. This plant is one of five free-forging installations from 600 to 4,000 tons capacity with a total value of over £$\frac{3}{4}$ million at present on order with Loewy.

EFCO FURNACES, LTD., has received orders valued at over £100,000 for heat treatment equipment to be installed in the new Rootes factory at Linwood, near Paisley, Scotland, where the new small Hillman car is to be produced. The orders cover the supply of a battery of closed-quench furnaces, tempering and reheating furnaces, endothermic atmosphere generators with automatic dewpoint controllers, automatic temperature controllers and charge handling machinery. In addition, Efco Furnaces, Ltd., has received orders for furnaces for the treatment of aluminium die cast components to be produced by Rootes in their die casting factory also being built at Linwood.

AEI-BIRLEC, LTD., have received an order for furnaces from Centrozap of Poland to the value of £153,000. The contract calls for the supply of two continuous twin-track, gas-fired gas carburising furnaces, together with washing machines, tempering furnaces, the conveyor tracks between these units, and certain other items. Also called for in the order are special atmosphere generators for the carburising furnaces, with automatic temperature and dewpoint control.

WILD-BARFIELD ELECTRIC FURNACES, LTD., have received from Crofts (Engineers), Ltd., Bradford—the power transmission engineers—an order for two gas-carburising furnaces of dissimilar size and a large forced air circulation equipment for tempering and stress relieving. A suitable cooling pit, oil quench tank having thermostatic control of quenchant temperature, circulating pump and cooler, together with relevant switch gear and control instrumentation will complete the installation.

THE UNIVERSAL DIAMOND CO., LTD., Unidex Works, Cross Lane, London, N.8 is reverting to the name of its parent company and will be known as L. De Vries & Son (Diamond Tools), Ltd., to avoid possible confusion with other firms embodying the title "Universal" in their name. Due to recent expansion of manufacturing capacity a first class diamond service is available, and a catalogue depicting the range of diamond products is obtainable on request.

MORGANITE ELECTROHEAT LIMITED, a member of the Morgan Crucible Group, have been appointed sole distributors in the United Kingdom for Norton Crystolon Hot Rods and Super Hot Rods. These are available for use as electric furnace heating elements for temperatures up to 1,575° C. and 1,700° C. respectively. These products are additional to the established range of Morgan "Crusilite" elements.

A LARGE shipment of refractory materials for export to New Zealand by General Refractories, Ltd., Sheffield, was despatched from works in the Genefax group at the beginning of December. 850 tons of refractories, destined for the largest plant of its kind in New Zealand, were consigned on the m.v. *Holmdale* on the vessel's maiden voyage.

I.C.I. Heat Treatment joins the *Harristocracy*

To professional decorators and "do-it-yourself-ers", Harris has long been a name to conjure with—or, rather, to decorate with.
And Harris, naturally, are determined that this state of affairs should continue—and even grow, both at home and overseas.
That's why they introduced a mirror finish for all their scrapers—and why they devised a blade hard enough to retain its edge, yet capable of being bent without breaking. It's a super-strong tool, with long-life sharpness, hollow-ground for extra flexibility, and mirror-finished for easy cleaning.
And Harris's new scraper could not have been produced without I.C.I.'s 'Cassel' Ajax Electric Furnaces to provide the heat-treatment.
Harris used to blank out their scraper blades from hardened and tempered strip; tool wear and maintenance was considerable—and production of the new blades at the required hardness would have been impossible. So Harris consulted I.C.I. Heat Treatment Service and installed their own heat-treatment plant.
Now, they blank out from annealed strip, and follow up with heat-treatment to give the desired hardness.
By using their own heat-treatment plant, Harris are able to ensure the clean surface necessary for mirror finishing; optimum hardness with minimum distortion and a blade sufficiently flexible, after hardening, to be pulled flat in the temper setting jig. Tool life at the blanking stage has been spectacularly lengthened and maintenance reduced to a minimum.

Harris would certainly agree that

IT PAYS TO CONSULT I.C.I. HEAT TREATMENT SERVICE

ICI
GENERAL CHEMICALS DIVISION

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1.

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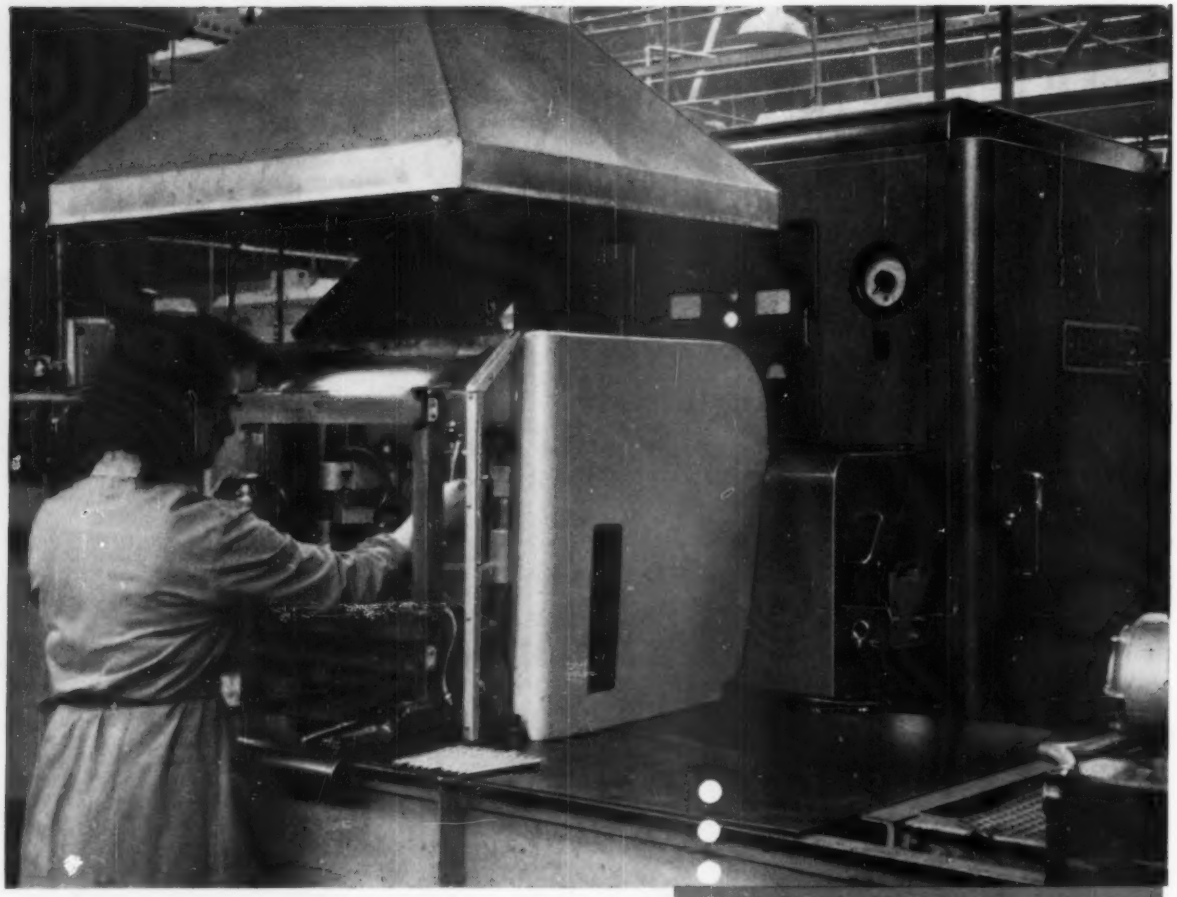


Wild-Barfield A.H.F. equipment is used by Wolf Electric Tools, Ltd., (manufacturers of the well-known Wolfcub drills etc.), for the hardening and tempering of small gears, shafts and pinions. Many other industrial concerns have found that Wild-Barfield A.H.F. induction heating speeds production, saves space and offers savings all along the line. Our engineers will be glad to supply further details and explain how Wild-Barfield A.H.F. equipment can help you.

WILD-BARFIELD A.H.F. equipment at WOLF ELECTRIC TOOLS LTD

WILD BARFIELD A.H.F.

Induction heating speeds production

WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS. Telephone: Watford 26091 (8 lines)

WB 64

NEWS AND ANNOUNCEMENTS

Post-Graduate Lecture Courses

Two post-graduate lecture courses have been arranged by the department of metallurgy in the College of Advanced Technology, Gosta Green, Birmingham 4, dealing with modern developments in extrusion and in cast iron, respectively.

The extrusion course of ten lectures is planned on successive Tuesday evenings, commencing January 23rd, 1962, at 6.30 p.m., and the course tutor is Mr. B. J. Meadows. The lectures, which will be given by a number of specialists in this field, will include critical surveys of theoretical aspects, and recent developments in the extrusion of steels and of non-ferrous metals generally. In addition to more conventional processes, the specialised techniques for the newer metals will also be discussed.

The cast iron course of ten lectures is planned on successive Wednesdays, commencing January 24th, 1962, at 6.30 p.m., and the course tutor is Mr. J. C. Billington. The lectures will be given by members of the British Cast Iron Research Association staff and will aim at a comprehensive survey of this field, including developments in melting practice, foundry sands and various types of plain and alloy cast irons.

Details and application forms for the courses can be obtained from the course tutors.

Titanium Price Reduction

THE two major producers of titanium and titanium alloys —Jessop-Saville, Ltd., and the Metals Division of Imperial Chemical Industries, Ltd.—have announced price cuts averaging 10–15%, but varying according to form and alloy. Titanium, the world's fourth most common constructional element, has three outstanding qualities—strength, lightness, and resistance to corrosion. It is now being supplied not only to the aircraft industry, for which it was originally developed, but also for many different purposes in the manufacture of chemicals, textiles, household equipment, etc. Increasing output and improvements in production techniques are reducing costs and enabling price reductions to be made.

Davy-United Mill for Park Gate

DAVY AND UNITED ENGINEERING CO., LTD., a member of the Davy-Ashmore Group, has secured a contract from The Park Gate Iron & Steel Co., Ltd., to build a 42 in. × 104 in. reversing blooming mill, complete with a full range of auxiliary equipment, for the new integrated steelworks which Park Gate are now establishing on a new site on the outskirts of Rotherham. The value of the contract is approximately £1 million.

Park Gate's development project has as its initial aim the increasing of annual ingot capacity from 425,000 tons a year to 800,000 tons a year. The increased output of steel which the new plant will make possible is intended to help meet both the internal needs of the T.I. Group,of which Park Gate is a member, in the production of steel tubes and other engineering products, as well as those of Park Gate's own customers.

The new Davy-United mill will be the primary rolling unit of the works and is being designed to roll ingots up to 5 tons in weight in carbon and rimming steels and certain low alloy steels. Driven by twin 3,000 h.p. motors, the mill will eventually supply blooms ranging from 5 × 5 in. to 14 × 14 in. square, to feed continuous billet and narrow strip mills which Park Gate also propose subsequently to install, as well as the existing finishing mills.

Wellman-Incandescent in India

IN view of their expanding business in India, The Wellman Smith Owen Engineering Corporation, Ltd., with their associated undertaking, The Incandescent Heat Co., Ltd., have now opened an establishment in Calcutta under the management of Mr. B. A. Harper. During recent times the activities of the Wellman-Incandescent group in India have increased considerably, and the opening of this new branch should facilitate the service which these companies provide to Indian industry.

The Wellman Corporation has taken an important part in the design and construction of the Durgapar Steelworks being responsible for the complete open hearth steel-making installation, the ingot soaking pits and reheating furnaces in the rolling mill department, coke oven machinery, cranes and special mechanical handling equipment. The activities of the Incandescent Heat Co. in India have been concerned largely with the supply of heat treatment furnaces for a wide range of industries, chemical and gas atmosphere plants, foundry equipment, etc. More than sixty Incandescent furnaces have been supplied to one important Indian steel foundry.

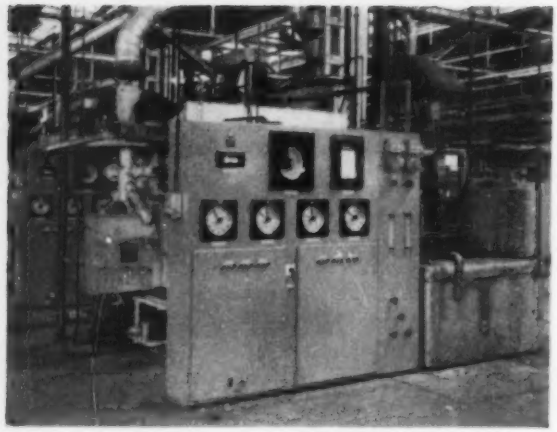
Aluminium Production Development

THE BRITISH ALUMINIUM CO., LTD., London, and Kaiser Aluminum and Chemical Corporation, Oakland, California, recently announced the successful joint development of a modified type of aluminium reduction cell utilising refractory hard metals as essential elements. Cells with these new cathode materials offer the first basic alteration to the electrolytic reduction process, on which the world's aluminium industry has been founded, since it was invented seventy-five years ago.

The two companies consider the development to be of major commercial significance, because it can substantially reduce production cost per pound of aluminium and also permit expansion of the capacity of existing facilities with relatively small capital expenditure. The development can lead to an improvement of up to 15% in cell operation. This can be achieved either (1) by a decrease in the energy consumption per pound of metal, or (2) by an increase in metal output per pot.

Both British Aluminium and Kaiser Aluminum are currently using the development in certain of their reduction facilities. They plan to continue making refinements in its application to existing cells in order to ensure further the successful adaptation of the development to all types of reduction cells.

The development was invented by research experts of B.A. in the early 1950s. Kaiser Aluminum joined with British Aluminium in the mid-1950s in a joint research



Automatic programme controllers are among instruments by Honeywell Controls, Ltd., recently installed at the Erdington, Birmingham, works of Hardy Spicer, Ltd., for heat treatment processes on vehicle transmission components and other parts. The illustration shows one of six panels controlling six furnaces: the programme controller is at top centre.

programme designed to carry forward the further development of the basic inventions. Since that time the two companies have co-operated in the development of the refractory hard metal materials and their application to both existing and new electrolytic reduction cells. The companies have also obtained basic patent protection in the principal aluminium producing countries of the world.

Refractory hard metals are chemical compounds of exceptionally high hardness and melting point which otherwise resemble dense, heat-resisting metal alloys. Typical refractory hard metals are the carbides and borides of titanium and zirconium.

Further details of the development will be given in a paper to be presented at the International Symposium on the Extractive Metallurgy of Aluminium to be held by the American Institute of Mining and Metallurgical Engineers in New York City as part of its annual meeting in February 1962.

Non-Destructive Testing Conference

THE FOURTH INTERNATIONAL CONFERENCE ON NON-DESTRUCTIVE TESTING is to be held in London from 9th to 13th September, 1963. The Council of the Institution of Mechanical Engineers have agreed to arrange the conference which is sponsored by the British National Committee for Non-Destructive Testing. Accordingly the council have set up an organising committee in collaboration with the British National Committee to plan this conference. The scope of the conference will include all aspects of non-destructive testing and papers will be admitted under the following tentative headings: (*i*) basic physics and selection of method; (*ii*) non-destructive testing in general structures including, for example, chemical plant, refineries, buildings, bridges, power plants, etc.; (*iii*) non-destructive testing in transport, including for example, ships, aircraft, etc.; and (*iv*) future needs in non-destructive testing. Prospective authors are invited to write in the first instance, giving proposed titles of papers, to the Secretary of the Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, for further information and for a guide to the preparation of papers. The final decision on acceptance rests with the council of the Institution.

A BISRA Research Section Renamed

IN recognition of the steady growth in the scope of its activities over recent years, the computer applications section of the British Iron and Steel Research Association's operational research department has now been renamed the systems evaluation section. The duties of the new section, which will be headed by Mr. D. H. KELLEY, will be able to carry out operational research investigations into the automation of large scale systems. The immediate programme will be to study the automatic production planning and scheduling of various kinds of steelworks, and to investigate the information requirements of steelworks management. The service to members which were previously supplied by the computer applications section, and which included operation of the computers in steelworks offices, and the training of Pegasus programmers, will be continued unchanged.

Re-organisation at B.W.R.A.

Under a new arrangement, made effective in November, the former Welding Process and Resistance Welding sections of the British Welding Research Association have been integrated into a single Welding Technology Department whose terms of reference include the carrying out of such research as is necessary to extend the range of usefulness of existing welding processes, to promote the effective use of welding methods, to assist in the selection of processes for particular applications and to provide basic data for the design of welding plant. Administration of the new department is the responsibility of Mr. P. T. Houldcroft, formerly the Association's Chief Metallurgist, who now becomes Head of the Welding Technology Department, with Mr. A. A. Smith, formerly in charge of the Welding Process Section, as Deputy Head. Complete administrative responsibility for, and control of, the metallurgical laboratory is assumed by Mr. H. F. Tremlett, the Deputy Director of Research, with Dr. R. G. Baker and Mr. J. G. Young as Chief Metallurgists in charge, respectively, of ferrous and non-ferrous researches.

Changes in B.S.I. Structure

CHANGES announced last month within the technical directorate of the British Standards Institution are designed to enable it more efficiently to meet a rising demand for standards from an ever-widening circle of interests, and to cope with the greatly increasing weight of international standards work. Hitherto, B.S.I.'s technical work has been handled internally within five sections. Now, the number of sections is increased to seven—the two new ones being concerned with (*a*) metallurgical and some engineering industries, and (*b*) safety and consumer standards; codes of practice work is now combined with building activities.

Lecture Courses

Three special lecture courses on metal topics to be held in the 1962 spring term have been organised by the

Division of Metal Science of the Borough Polytechnic, London, S.E.1. The first, dealing with present-day Methods of Metal Surface Preparation for Metal Finishing, will consist of six lectures given by specialists on consecutive Thursday evenings at 7 p.m. commencing the 11th January, 1962. The course on Corrosion Testing will consist of six lectures given by specialists on consecutive Thursday evenings at 7 p.m. commencing the 22nd February, 1962. The third course, on Modern Developments in Die-Casting Practice, will consist of four lectures given by specialists on consecutive Wednesday evenings at 7 p.m. commencing the 7th March, 1962. The fee for each course is ten shillings.

Young People's Welding Lecture

THE INSTITUTE OF WELDING is organising a Christmas lecture for young people entitled "Joining the Modern Way." It will incorporate a number of demonstrations and will be delivered by Mr. John Strong, a past-president, at the headquarters of the Institute, 54 Princes Gate, S.W.7, on Thursday, 4th January, 1962, at 11 a.m. Admission will be by ticket only, obtainable from the Secretary, The Institute of Welding, 54 Princes Gate, Exhibition Road, South Kensington, London, S.W.7.

Platt Metals, Ltd.

PLATT METALS, LTD., are pleased to be able to announce that the labour trouble they have had at their works for the past six months is now over. It has been a long and hard struggle and Platt Metals wish to express their gratitude to their many friends from whom they received co-operation during the troublous period.

Personal News

FOLLOWING the recent resignation of MR. A. M. SIMMERS, who has taken up an appointment with Vickers, Ltd., MR. P. H. MORWOOD has been appointed secretary of English Steel Corporation, Ltd., and MR. A. TAYLOR, special director, has been appointed chief accountant. Mr. Morwood is also secretary of the United Kingdom subsidiaries of the E.S.C. group, and Mr. Taylor is chief accountant of the wholly owned subsidiaries.

MR. C. J. EVANS has been appointed southern area sales manager of Efco Furnaces, Ltd. Mr. Evans was formerly sales manager of the furnace department of The General Electric Co., Ltd.

MR. R. JOHNSON has been appointed works manager (melting shops) and MR. R. WOGIN has been appointed works manager (rolling mills) at United Steel Cos.' Appleby-Frodingham Steel Co. branch.

MR. R. E. ANSELL has assumed the title of sales director of Henry Wiggin & Co., Ltd., and MR. C. BOWLES has been appointed to the position of sales manager, responsible to the sales director.

MR. G. S. PALMER has joined James Booth Aluminium, Ltd., Birmingham, as chief accountant.

MR. G. N. F. WINGATE, director and general manager of Distington Engineering Co., Ltd., has been appointed chairman of Barrow Steel Works, Ltd., following its recent acquisition by The United Steel Cos., Ltd., from the Iron and Steel Holding and Realisation Agency. MR. A. JACKSON, technical adviser on steelmaking to United Steel, MR. T. G. MARPLE, general manager of Barrow Steel Works, and MR. E. T. SARA, assistant general sales manager of United Steel, have been appointed directors of Barrow Steel Works. MR. A. J. PEECH, deputy chairman and general managing director of United Steel, remains a director. SIR WALTER BENTON JONES, the chairman of United Steel, and MR. LANGTON HIGHTON, have resigned from the Barrow board.

MR. G. B. R. FIELDEN, F.R.S., has resigned his several directorships in order to join the board of Davy-Ashmore, Ltd., as technical director. Mr. Fielden will be based at the group's London headquarters at 15 Portland Place, W.1., and will also be joining the boards of the principal operating companies of the Davy-Ashmore group.

MR. W. E. A. REDFEARN, director of English Steel Corporation, Ltd., and managing director of English Steel Forge and Engineering Corporation, Ltd., has joined the board of Firth-Vickers Stainless Steels Ltd.

BRIGADIER A. LEVESLEY, O.B.E., M.C., T.D., has been appointed president of the Welded Tool Manufacturers' Export Association, and of the Welded Rod Manufacturer's Association in succession to MR. R. P. WALLACE of Jessop-Saville, Ltd.

PROFESSOR A. H. COTTRELL, F.R.S., Goldsmiths' professor of metallurgy in the University of Cambridge, has been awarded the Hughes Medal of the Royal Society for his distinguished work on the physical properties of metals, particularly in relation to mechanical deformation and to the effects of irradiation.

MR. K. A. SMITH, who for the past two years has been a director of Firth Cleveland Steel Strip, Ltd., of Tipton, Staffs., has been appointed a director of Firth Cleveland Steel, Ltd., and of the associated company, J. J. Habershon & Sons, Ltd. He will have full executive responsibility over the whole field of steel strip production, and will be based at Holmes Mills, Rotherham.

MR. B. SMITH has been appointed a director of Osborn-Mushet Tools, Ltd.

MR. F. B. HOLMES, chairman and managing director of W. C. Holmes & Co., Ltd., retired as managing director on 31st October. He retains the position of chairman of the company, of the holding company, B.H.D. Engineers, Ltd., and of those member companies of which he is at present chairman. Mr. Holmes is succeeded as managing director by MR. A. G. M. HENSHAW. DR. W. T. CROSBY, manager of the gas cleaning division has been appointed to the board.

MR. M. LYTH has recently been appointed director of supplies to Griffin & George (Sales), Ltd. This is a new post created to meet the growing need for the buying and allied functions to be represented at board level. Until his new appointment Mr. Lyth was managing director of Griffin & George (Scientific Instruments), Ltd., a subsidiary company which manufactures the Griffin specialist range of scientific instruments.

THE DROP FORGING RESEARCH ASSOCIATION announces that MR. F. E. L. COPLEY and MR. A. C. HOBDELL have joined the staff.

MR. A. FUDGE has been appointed director and general manager of The Tenuous Steel Co., Ltd., of Rotherham, Yorks., by Firth Cleveland Steel, Ltd. Since 1956, he has been company secretary of Firth Cleveland Steel Strip, Ltd., of Tipton, Staffs., and for the time being he will retain this position.

MR. C. F. WILLIAMSON has been appointed sales manager of the compressor division of Tilghman's, Ltd., a member of the Staveley group of companies. Tilghman's sales force has been strengthened by the appointment of the following compressor specialists: MR. R. BUSHELL (Lancashire and Yorkshire), MR. A. H. STENNING (London), and MR. J. SMITH (North East Coast and Scotland).

MR. C. R. WHEELER becomes deputy chairman of Associated Electrical Industries, Ltd., on 1st January, 1962. He will also be deputy chairman of the AEI management companies. Mr. Wheeler's appointment as a vice-chairman of AEI was announced in August 1960. At that time he was chairman of the Guest, Keen, Iron and Steel Co., Ltd., and a director of several steel and allied companies. He was president of the Iron and Steel Institute for the year 1958-1959 and is this year's president of the British Iron and Steel Federation.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION has appointed MR. A. G. SHAKESPEARE, as head of its steelmaking laboratories at the Sheffield research station. at the time of this appointment Mr. Shakespeare was in charge of the Association's work on hot strip processing in the Sketty Hall laboratories at Swansea.

IT is announced that MR. A. E. THORNTON, special director and foundry general manager of Firth-Vickers Stainless Steels, Ltd., is, on medical advice and at his own request, retiring on 31st December, 1961, after forty-five years with the company and its parent company Thos. Firth & John Brown, Ltd.

THE Ore Mining Branch of The United Steel Cos., Ltd., announce that MR. F. IBBOTSON, formerly manager of Dragonby mine, has been appointed assistant group manager, underground mines; MR. T. P. S. BAXTER, manager of Santon mine, has succeeded Mr. Ibbotson as manager of Dragonby mine. MR. J. DARRAGH, undermanager at Santon mine, becomes manager of Santon mine, and MR. A. S. MARTIN, previously a deputy at Dragonby, is appointed undermanager at Santon.

DORMAN, LONG & CO., LTD., announce that MR. J. JACK, previously financial director of the company, has been appointed managing director—group finance and administration, and that MR. T. YOUNG is now secretary.

MR. E. R. HENSCHKER and MR. R. M. L. ELKAN have been appointed directors of The Loewy Engineering Co., Ltd., of Bournemouth, which designs and builds hydraulic presses and rolling mills and is a member of the engineering division of Tube Investments Ltd. Mr. Henschker started with the company in 1937, becoming chief engineer of the rolling mill division in 1955. Mr. Elkan joined Loewy in 1947, and was later appointed assistant to the managing director of the hydraulic division.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LTD., announce the appointment of MR. E. D. WOODHOUSE as their sales engineer for the North of England and Scotland. Mr Woodhouse will operate from 8, Highfield Road, Grove Hill, Middlesborough. (Tel. 43112).

MR. J. SAMUELS, for six years a member of the board, has been appointed managing director of Winston Electronics, Ltd., Shepperton, Middlesex. MR. W. A. BRIDGES continues as chairman of the board, relinquishing the managing directorship assumed in August.

Obituary

WE regret to record the death of the following:—

DR. EDWIN GREGORY—a director of Edgar Allen & Co., Ltd., for fifteen years and chief metallurgist from 1944 until his retirement from executive duties last March—who died on 7th November 1961 at the age of sixty-seven. A Sheffield man, resident in Rotherham, Dr. Gregory was known throughout the English-speaking world for his books on metallurgical subjects, some of which are standard works in educational establishments.

Dr. Gregory was a member of the court of governors of the University of Sheffield, thus serving the university in which he had been a brilliant student and later a lecturer in the department of metallurgy from 1921 to 1937. In the latter year, he received the Freedom of the Sheffield Trades Technical Societies, along with the Ripper Medal, as a token of appreciation for his services.

During his later life, Dr. Gregory served on many national and local committees. Prominent among these interests were his work as a Governor of the National Foundry College; as one of the original council members of the British Iron and Steel Research Association; and as chairman of B.I.S.R.A.'s standard methods of analysis committee. His interest in metallurgical analysis was further exemplified by his chairmanship of the Bureau of Analysed Samples, Ltd., whose main activity is the provision of standard steels for analytical purposes. He played an important part in the formation of the British Steel Castings Research Association, and was a member of its council and finance committee, as well as research committee chairman. Dr. Gregory was a past president of the Institution of Engineering Inspection, and a former chairman of the Institution of Metallurgists' examination committee.

MR. K. L. OLIVIER, general manager of the David Brown machine tool and tool divisions, and a director of David Brown Industries, Ltd., who died on 18th November, 1961, aged fifty. Mr. Olivier joined Muir Machine Tools., Ltd., as assistant chief draughtsman in 1937, and shortly after the David Brown Organisations acquired the company in 1944 he was appointed factory manager. In 1956 he became general manager of the machine tool and tools divisions and in 1959 a director of David Brown Industries, Ltd. An active member of Admiralty-Vickers Gearing Research Association from its inception, Mr. Olivier assisted the British Standards Institution in establishing standards relative to turbine gearing.

MR. FRANK THOMPSON-SCHWAB, chairman of the Darwins group of companies and of Balfour and Darwins, Ltd., who died in a nursing home on Friday, 1st December, 1961, at the age of seventy. A London stockbroker, Mr. Thompson-Schwab built the Sheffield firm of Darwins Ltd., from near bankruptcy to its present flourishing position. Under his chairmanship the Darwins group grew to include Darwins, Ltd., Andrews Toledo, Ltd., Wardsend Steel Co., Ltd., the Sheffield Forge and Rolling Mills Co., Ltd., J. Stead & Co., Ltd., and Darwins Bright Steels, Ltd. Not only did he engineer the expansion of the Darwins group, but he was co-architect with Lord Riverdale of the merger joining Darwins to Arthur Balfour & Co., Ltd. Mr. Thompson-Schwab became chairman of the holding company, Balfour and Darwins, Ltd., with Lord Riverdale, chairman of Balfours, as deputy chairman.

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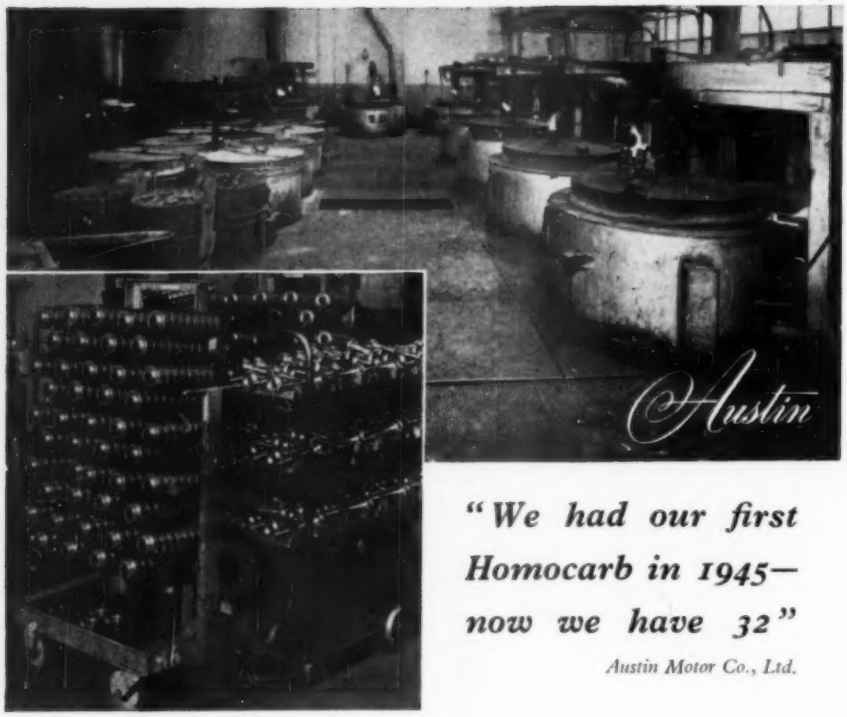

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Austin Motor Co., Ltd.

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WE are indebted to the Austin Motor Company for the above photograph of part of the Homocarb Electric Gas Carburising Furnaces at their Longbridge Works.

Originally, in 1945, one single furnace was purchased, the present extensive installation having been built up following their earlier experience.

Homocarb with its twin advantages of forced circulation and exact temperature time control has won world-wide recognition as will be seen from the following list of some important users.

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RECENT DEVELOPMENTS

MATERIALS : PROCESSES : EQUIPMENT

Adjustable Wall Thickness Gauge

An addition to the standard range of Teddington air gauges is an adjustable gauge designed to measure the wall thickness of plain bearings, cylindrical bushings and similar parts. This gauge will measure components from 1½ in. to 7½ in. I.D., and with up to ⅝ in. wall thickness. In addition to thickness, the gauge will measure I.D./O.D. concentricity by variation in wall thickness as the part is rotated in the gauge. Open gauging nozzles are used, thus there are no contacts to mark the work piece. In addition the tungsten carbide wear surfaces are superfinished to a surface finish of approximately one micro-inch. Adjustable support arms are fitted but these play no part in measurement, and merely serve to support the work piece in the gauging position.

A particular feature of the gauge is the ease of setting up. A pneumatic span-setting master is built into the gauge and the pneumatic calibration can be readily checked by turning a knob. All that is then required is a nominal size master to enable the adjustable upper nozzle to be positioned correctly for the particular size of work piece. The nominal master may be either a flat slip gauge or a work piece of accurately known size.

To give fast, easy, measurement the gauge is designed with the maximum clearance and this is 0·002–0·002 in. beyond the thickest part that can be measured at any particular setting. The indicator gauge is liquid filled and sealed, giving a fast positive pointer movement. The gauge may have one of two measuring ranges—0·001/0/0·001 in. reading to 0·0001 in. (magnification 1,800) or, 0·002/0/0·002 in. reading to 0·0002 in. (magnification 900). An air supply at any pressure between 60 and 150 lb./sq. in. is required, and the gauge is supplied complete with air filter with supply pressure gauge and 4 ft. of connecting hose.

Teddington Industrial Equipment, Ltd., Sunbury-on-Thames, Middlesex.

Grade II Tin-Nickel Plated Weights

Griffin & George have produced a new set of analytical weights which, besides being of interest to educational authorities, can also be used in industrial laboratories for routine weighing. They are manufactured to the former N.P.L. Class B standard. The weights are of brass, finished tin-nickel plate and polished, and are of two piece construction. Tests carried out at the National Physical Laboratory have shown that the tin-nickel alloy finish has no undesirable magnetic properties and is resistant to corrosion by alkalis, nitric acid and other acids at normal temperatures. The alloy is also very hard wearing and does not tarnish.

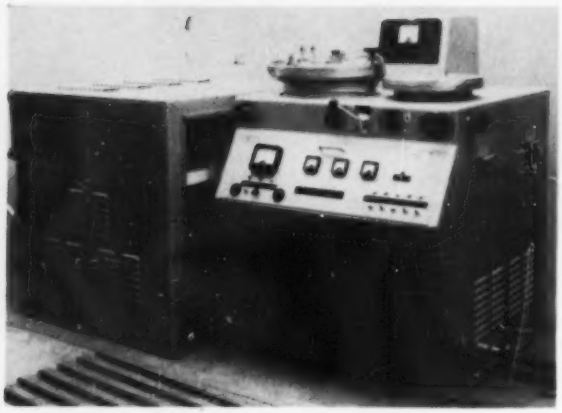
The sets are supplied in plastic cases with moulded blocks of polythene to hold the unit weights. The fractional weights are contained in a removable plastic tray with the separate compartments inclined and figured, and are protected from dust by a transparent plastic cover. In addition, two 10 mg. riders and one set of lightweight white plastic forceps are included. Sets without fractions, for use with weight loaded balances, are also available.

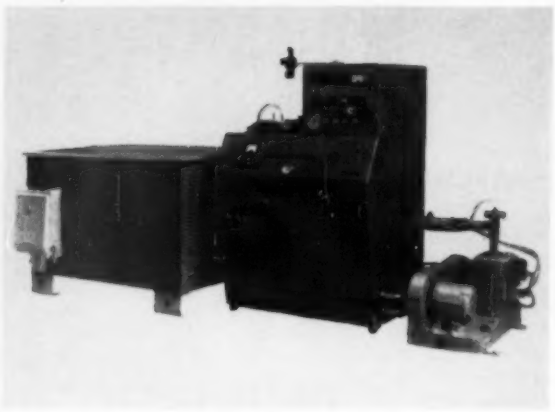
Griffin & George, Ltd., Ealing Road, Alperton, Wembley, Middlesex.

Vacuum Sintering Furnace

Vacuum Metallurgical Developments Ltd., have recently developed a high vacuum sintering or heat treatment furnace which is available in two versions. In the manually controlled version seen on the left the operation cycle is as simple as possible, in that the charge is loaded on a tiered tray assembly and placed in the chamber; the charging cover replaced, the vacuum system brought into action and, finally, the resistance heater switched on. The operating temperature can be as high as 2,400° C. at pressures better than 10^{-5} mm.Hg. Such furnaces are currently sintering tantalum capacitors for manufacturers in the United Kingdom.

The heating element, fabricated from tantalum or tungsten sheet in three segments, forms a circle 3¾ in. diameter × 15 in. long, each segment being riveted in turn to tantalum or tungsten sheet conductors leading to connections on the bus bars. These connecting sheets, as well as acting as conductors, support the element. Radiation shields fabricated from tantalum sheet are





again in segments and form a complete enclosure around the element. The entire assembly is held by tantalum nuts, screws and spacers, thus eliminating the use of troublesome refractories. The element and radiation shield assembly is readily detachable from the chamber—simplifying replacements and cleaning.

The entire unit is enclosed in a steel cabinet attractively finished in stove grey enamel, and operator fatigue is reduced by centrally mounted instruments and controls. Transformers housed in a second cabinet supply power to the heating element ; variation being provided by an auto transformer controlled by a rotary switch or core reactor system. Safety interlocks protect against water failure, and independent fuses to each main component are fitted as standard equipment on both versions of the furnace.

The second version has the same general design as the manually-operated furnace but embodies semi-automatic controls. A multi-position rotary switch ensures correct sequence, each position being clearly marked, and overriding switches enable any individual operation to be accomplished without the use of the sequence switch. A sequence switch is again provided for the first stage of the operating cycle, but the heating control can be slaved to the pressure instrumentation, incorporating the latest techniques to ensure the longest possible life of the rare metal elements and radiation shields, as well as allowing the plant to be operated by a semi-skilled operator. Outgassing rate is automatically controlled by presetting the pressure guage at the required level, the rate of heating being then controlled so that the pressure never exceeds the guage setting.

Vacuum Metallurgical Developments, Ltd., Alma Works, Levenshulme, Manchester, 19.

Aerosol Stencil Ink

J. & H. ROSENHEIM & CO., LTD., who have for some time marketed black stencil ink in aerosol dispenser, can now supply these in the following range of colours : black, blue, green, white, red, orange, yellow and aluminium. They are suitable for stencilling boxes, cartons, crates, metal drums, bales, tarpaulins, concrete stone, etc., on porous and non-porous surfaces, the colours being waterproof and non-flaking. They are particularly useful for colour coding on metals or other materials for speedy identification or inspection marking : blue ink can be used as a design layout fluid. Advantages are that the ink is quick drying, waterproof and weatherproof, efficiency is increased, there is no waste or evaporation, application is easier, and there is no wear on the stencils.

J. & H. Rosenheim & Co., Ltd., Craigton Industrial Estate, Glasgow, S.W.2.

Antimony-Clad Nilo-K

JOHNSON MATTHEY announce that they can now offer to manufacturers of semiconductor devices sample quantities of Nilo-K strip clad on each side with 0·5% gold-antimony. It is hoped that production quantities will be available early next year. The strip is available in widths between $\frac{1}{32}$ in. (2·4 mm.) and 2 in. (50·8 mm.) and in thicknesses down to 0·005 in. (0·13 mm.). The thickness of cladding that can be supplied on each face is either 11·5% or 18·75% of the total thickness.

Johnson Matthey & Co., Ltd., 73-83, *Hatton Garden, London, E.C.*1.

Differential Cathode Ray Polarograph

THE Davis differential cathode ray polarograph is the improved commercial version of the original differential cathode ray polarograph designed by H. M. Davis at U.K.A.E.A., Woolwich, and recently substantially redesigned by him at Southern Analytical, Ltd., in respect of signal/noise ratio, drift and frequency response. The reduction in noise level greatly facilitates measurements at high sensitivities, and the increased amplifier bandwidth is particularly valuable in the study of reductions or oxidations occurring at closely adjacent potentials, when the first or second time derivative of the cell current waveform is required to obtain maximum resolution. For the first time reversed potential sweep facilities are included on all four modes of operation ; subtractive, comparative, derivative and single-cell operation. A leaflet describing the development of the differential polarographic technique and its advantages is available from the manufacturers.

Southern Analytical, Ltd., Frimley Road, Camberley, Surrey.

Non-Metallic Shotblast Abrasive

A NON-METALLIC shotblast abrasive, No-Met, is announced by Bradley's (Darlaston), Ltd., a member of

the Staveley group of companies. The new product is less than one-fifth the price of the conventional metallic abrasive. Shotblasting is generally recognised as the best way of preparing large areas of steel work for painting, but site conditions may prevent recovery of the abrasive material. No-Met was developed to fulfil the demand for a cheap, expendable abrasive for this type of work. Recent trials on bridges, ships' hulls and oil tanks have left steel surfaces with an excellent key for priming paints. No-Met is free of silica and thus complies with the shotblasting regulations.

Bradley's (Darlaston), Ltd., Darlaston Iron Works, Darlaston, Staffs.

Hard Aluminium Foil

A NEW hard aluminium foil—NS 4—in thicknesses down to 0·025 mm. is being rolled for the first time in this country by Venesta Foils, Ltd. NS 4 differs from commercial purity aluminium in containing 1·8–2·7% magnesium and up to 0·5% each of manganese and chromium. The production of foil from this alloy meets a call from industry for a foil of greater stiffness and strength than can be rolled from commercially pure aluminium, or from the 1·25% manganese alloy, NS 3. This demand comes from industries as widely apart as the aircraft industry, where it is used as the honeycomb centre of flooring, to the display industry, for the manufacture of collapsible foil Christmas trees. Both use NS 4 foil in the hard temper. In this temper and in 0·06 mm. thickness, NS 4 has a tensile strength of 16–18 tons/sq. in., as against 9 tons/sq. in. for commercial purity aluminium and about 11–12 tons/sq. in. for NS 3.

Venesta Foils, Ltd., Thorn House, Upper St. Martins Lane, London, W.C.2.

Griffin-Citenco Stirring Motors

GRIFFIN & GEORGE have added to their range of laboratory stirrers the new Griffin-Citenco stirring motors, described in leaflet P.2118. This motor is of particular use in the preparation of chemicals involving the use of liquids with high viscosity, since it has variable speed adjustment and also the ability to produce high torque at low speeds through a reduction gearbox.

Among the features incorporated in this motor is a dynamically balanced armature in sleeve bearings and integral fan cooling. A point of special interest is the combined bracket and bosshead, which permits the stirrer to be aligned in three different planes at right angles. The stirrers are usually attached to the motor shaft by a short length of rubber or plastic tubing, but a special chuck is available as an accessory which will accommodate stirrers of $\frac{3}{32}$ in. diameter. Three types of motor are available, each giving differing max./min. speeds and torque.

Griffin & George, Ltd., Ealing Road, Alperton, Wembley, Middlesex.

New Oscilloscope Camera

A NEW oscilloscope camera manufactured by the DuMont Division of the Fairchild Camera & Instrument Corporation has been introduced into the United Kingdom by Aveley Electric, Ltd. This oscilloscope camera, designated Type 450 is new in every concept, from versatility, to simplicity in operation. The interchangeability of

backs, and the choice of four lens combinations enable operators to obtain permanent records in any size from 4 × 5 in. down to 35 mm. in a wide variety of object/image ratios—on regular or the new 10-second Polaroid print products. A sliding back with detented looking positions permit multiple precision-spaced exposures per frame. The shutter is a synchro shutter for arming or triggering oscilloscopes with remote single sweep feature. Focussing by helical rack and pinion mechanism enhances precision results and maintains the optical axis perpendicular to the film plane. Full data recording facilities are available, and remote operation is possible by means of a solenoid power pack.

Aveley Electric Ltd., Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

Chromating Processes

To fulfil a requirement in industry for a chromating process suitable for large scale production, Pyrene have introduced the Bonderite '250' range of processes. These are designed to operate at room temperature and to produce on hot-dipped galvanised steel, electro-zinc plated steel or zinc-based alloys, chromate coatings which give considerable corrosion protection, and form an excellent surface for subsequent painting. The range at present consists of three processes.

Bonderite '250' is specifically formulated to produce a colourless coating with reasonable corrosion resistance, that would be particularly useful for preventing "white rusting" of articles during storage, and in other circumstances where a coloured film is considered undesirable. Bonderite '251' also produces colourless coatings but with improved corrosion resistance. When submitted to salt spray tests this process showed a considerable increase in corrosion resistance over other colourless chromate coatings. Bonderite '255' produces a heavier yellow-coloured chromate film with the high corrosion resistance associated with coatings of this colour. Ease of chemical control and low chemical costs are major advantages of the Bonderite '250' range.

The Bonderite '250' series has been extensively tested in the Pyrene laboratories, and is now in full scale production use. It is expected that Bonderite '250' will be delivered in bulk by road tanker to at least one large customer later this year.

The Pyrene Co., Ltd., Metal Finishing Division, Great West Road, Brentford, Middlesex.

Pure Cobalt Strip

COMMERCIALLY available for the first time, pure cobalt coiled strip with good ductility and workability is now offered by the Canadian firm, Sherritt Gordon Mines, Ltd., in thicknesses ranging from 0·005 in. to 0·025 in. and widths of ¼ in. to 6 in. Pure cobalt metal in strip form has not hitherto been commercially available because it was said to lack ductility and workability. The improvement in properties now attained is said to be due to the purity of the metal (99·9%) which is made by direct rolling of the company's pure cobalt powder.

Heating close-packed hexagonal cobalt to temperatures above 420° C. results in a face-centred cubic structure, but, on cooling, the reverse change is sluggish, and the formation of a completely hexagonal structure is retarded. The type of heat treatment and the eventual proportion of the two crystal phases present after cooling have an effect on the ductility of the cobalt. Annealing restores the ductility after cold working: cobalt strip cold rolled to a 25% reduction has a tensile strength of 74 tons/sq. in. and an elongation of 0·5%, and in the annealed condition a tensile strength of 51 tons/sq. in. and an elongation of 15%.

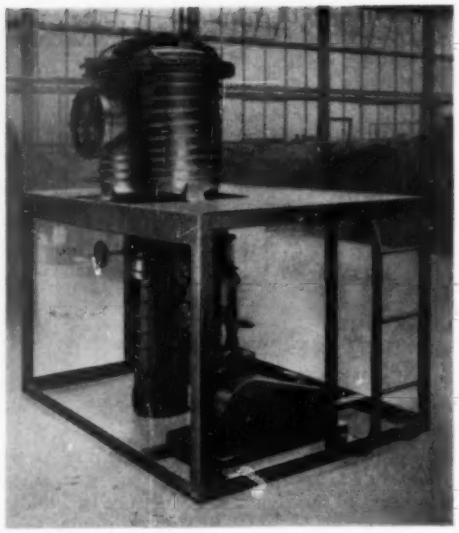
With the improvement in ductility cobalt strip becomes an important design material for applications where corrosion resistance and high strength at high temperatures are essential. The excellent magnetic properties of the metal make the use of cobalt strip for magnetic tape for computers a promising application.

Sherritt Gordon Mines, Ltd., 25 King Street West, Toronto, 1, Canada.

Vacuum Brazing Furnace

AN electrically heated, cold retort furnace specially designed for brazing components in vacuum, has been introduced by Royce Electric Furnaces, Ltd. The furnace is fitted with a molybdenum wire element providing temperatures up to 1,200° C., and operating vacua down to 10^{-5} mm. mercury can be obtained. The furnace chamber is a water-cooled, heavy-guage steel cylinder, domed at the bottom and having a removable domed cover to give access to the interior. It is mounted on a floor standing framework having a substantial top plate to provide a platform for the operator.

The furnace provides a work space 8 in. in diameter and 8 in. high, the charge being placed within the cylindrical element on a support made up of molybdenum rods with alumina top covers. The element is surrounded by radiation screens of Nilo K with an inner screen of molybdenum. Screens are assembled with molybdenum tubes and spacers and are housed in a steel canister supported within the chamber. Another assembly of radiation screens of the same materials provides a removable top cover. The element operates at a low voltage supplied by an infinitely variable voltage regulator transformer. Temperatures are controlled



automatically with a two point recorder housed in a wall mounting panel. Leads to the thermocouples can be taken through the molybdenum tubes in the radiation screen assembly without disturbing the whole assembly.

The furnace is supplied as a packaged unit complete with control gear and Edwards Speedivac pumping equipment which is mounted beneath the operator's platform.

Royce Electric Furnaces, Ltd., Albert Drive, Sheerwater, Woking, Surrey.

Emidec 1100 Computer

THE new-look Emidec 1100 data processing system has a faster line printer, larger fast access store, twice the transfer rate to and from magnetic tapes, and a greatly increased tape reel capacity. Line printing speed is increased from 300 lines per minute to almost 1,000 lines per minute and six copies are produced simultaneously instead of four, by use of the new EMI-Anelex printer.

Capacity of the fast access magnetic core store is increased from 1,024 to 4,096 words, consisting of six alpha-numeric characters or 11-decimal digits. This gives facilities for greatly increased data and programme storage. The first of these stores was included in the most powerful Emidec 1100 computer yet made, which was delivered recently to British European Airways' head office at Ruislip. Peak data rate to and from magnetic tapes has been doubled, from 20,000 characters per second to 40,000 characters per second. There is also an increase in the number of characters stored on one reel of tape, from 5 million to over 7 million characters.

EMI Electronics, Ltd., Hayes, Middlesex.

Correction

SPEEDICUT VANLEDA HIGH SPEED STEEL

WE regret that the item dealing with Speedicut Vanleda High Speed Steel, on page 248 of our November issue was wrongly attributed to Firth Brown Tools, Ltd. The makers are in fact Thos. Firth & John Brown, Ltd., Atlas Works, Sheffield, 4.

CURRENT LITERATURE

Book Notices

PROGRESS IN POWDER METALLURGY—1961

Proceedings of the 17th Annual Technical Meeting sponsored by the Metal Powder Industries Federation. 195 pp., 8 × 10 in., cloth bound. Available from the Federation, 60, East 42nd Street, New York 17, N.Y., U.S.A. $12

ADVANCES in powder metallurgy applications, including the powder metallurgy of beryllium and titanium, are detailed in the proceedings of the 17th Annual Technical Meeting sponsored by the Metal Powder Industries Federation. Besides covering the manufacture of beryllium sheet from powder and the production of high strength sintered parts from titanium powder, the proceedings also contain papers on the influence of fabrication techniques on the electrical and magnetic properties of sintered metals; a new look at hardness-strength relationships in sintered metals; new developments in furnaces for high temperature sintering; effects of lithium stearate on the properties of brass compacts; the strengthening effects of copper in infiltrated iron parts; the effects of controlled oxidation prior to sintering in iron and iron alloys; the use and advantages of metal powders in welding electrode coatings; and grain oriented 1 : 1 nickel-iron soft magnetic alloys made from powders.

A special symposium published in the proceedings covers advances in powder metallurgy tooling and compacting techniques. These include papers on a new approach to the study of powder compaction; the development and design of compacting presses for the production of large powder metallurgy parts; and the application of electrical discharge machining to powder metallurgy tooling. A special paper on the handling of metal powders for powder metallurgical applications is given along with a 1961 Progress Report detailing the growth of powder metallurgy in terms of powder consumption. Figures are shown covering the period 1945-1960 in the case of iron powders and 1952-1960 in the case of copper and copper-base powders. Breakdowns according to industry usage are also given. An historical review of the origins of the powder metallurgy industry in the United States appears in the proceedings as part of the M.P.I.F. Powder Metallurgy Pioneer Award citation to Roland P. Koehring.

A special feature of "Progress in Powder Metallurgy—1961" is a lecture-report on the fundamentals of powder metallurgy, stressing the influence and nature of creep in powder metallurgy products, presented by Professor Fritz V. Lenel, a well-known powder metallurgy authority at Rensselaer Polytechnic Institute.

CONTROL OF AIRBORNE DUST

By W. D. Bamford. 9¼ × 7 in., 480 pp., 250 illustrations, fully bound, dust cover. Published by The British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham. 84s. (65s. to members of the Association).

IN recent years the rapid mechanisation of foundry processes has made it essential for the principles of dust control to be more fully understood. To this end, on the recommendation of The Joint Iron Council, the British Cast Iron Research Association in 1950 established a foundry atmospheres section to provide an advisory service to the industry, and to undertake a long-term programme of research to determine the nature and extent of the problems involved in dust control in foundries. "Control of Airborne Dust" is based on the notes accumulated by the author in the course of his work as leader of the B.C.I.R.A. foundry atmospheres section, supported by previous experience in fan engineering and ventilating practice. The work from which this book derives is the result of the foresight and encouragement of the former director of the association, Dr. J. G. Pearce, C.B.E., who initiated the research programme and made the experimental resources available.

"Control of Airborne Dust" is intended as a text and reference book for those engaged in airborne dust control engineering. It will also be of value to students of environmental health and to all those who are seeking to establish a sound scientific basis for the control of dust. The book defines the problems to be solved and the principles on which their solution was approached; it goes on to show show how these principles can be applied in practical terms. "Control of Airborne Dust" is divided into fifteen chapters and the details of the foundry and laboratory investigations undertaken are tabulated and illustrated graphically in a copious appendix. The book is well illustrated throughout and the carefully selected index makes for easy reference to specific information.

In the early chapters the formation and dispersal of dust and fumes and other fundamental factors in foundries such as thermal currents and cross draughts, are described. The relative merits of side-, down- and top-draught exhaust systems and methods of predicting exhaust air volumes to obtain specific velocities are then discussed. Control of dust produced during sand cooling and by abrasive wheels is considered and three chapters are devoted to air cleaning and fans. The practical application of exhaust system design principles is considered at length and there is a short chapter on the related subject of heating of workshops.

The 480 pages of "Control of Airborne Dust" which include some 250 illustrations and diagrams will make a significant contribution to the understanding and solution of the problem of dust control in foundries, and will be of use and interest to workers in the same field in many other industries.

Trade Publications

THE value of borax to the wire drawing industry—where it is used in the neutralising of pickling acid and as a lubricant carrier—has been confirmed by the steady increase in its use since the war. A new publication, "Borax in Wire Drawing," summarises the practical experience gained during this period, and contains tables and data designed to be of help to members of the industry who are using or are intending to use borax. Copies of the booklet are available free on request from Borax Consolidated, Ltd., Borax House, Carlisle Place, London, S.W.1. French and German editions can also be supplied.

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THE Power-Gas Corporation, Ltd., designs, supplies and erects plant and equipment for the chemical, petrochemical, petroleum, gas, iron and steel and nuclear energy industries. The company provides a complete construction service from flow sheet or from technical designs, supplied by client, to completion of erection. All aspects of constructional engineering, including civil, mechanical and structural are included in this service and a handsome new illustrated brochure describes various aspects of these activities with the help of numerous illustrations from many industries.

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Factory Heating—2

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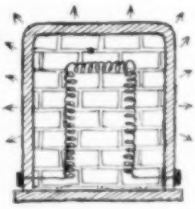
'OFF PEAK' ELECTRIC HEATING

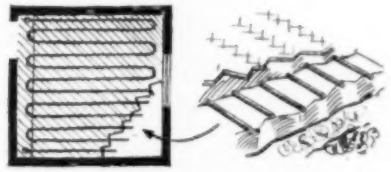
Because the 'off peak' load makes use of generating and distributing equipment when it would otherwise be idle or underloaded, it is attractive to the Electricity Boards, who offer cheap 'off peak' tariffs. Three types of 'off peak' heating systems are available, namely:

(a) Hot water storage heating: This consists of a conventional hot water radiator or panel heating system through which hot water from a large storage vessel is circulated. The water in the storage vessel is heated electrically during the 'off peak', low tariff hours and is circulated when required through the radiators or panels.

(b) Block storage heaters: These heaters consist essentially of a number of firebrick blocks which are heated up during the 'off peak' hours by means of suitable electric heating elements. The storage heaters are clad with a layer of suitable heat-insulating material and are housed in a sheet metal casing, the design being such that the stored heat is gradually dissipated throughout the day by means of radiation and convection from the casing. The great advantage of this method is that these heaters can easily be installed in existing buildings.



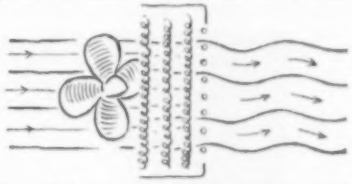
(c) Floor warming: In an 'off peak' floor warming installation, electric heating cables or ducts housing withdrawable cables are embedded in the concrete floor of the building. The cables are switched on and the floor is heated up during the 'off peak' hours, and the mass of concrete and screed of the finished floor has sufficient thermal storage capacity to heat the building during the period when current is not available. This method is only applicable to new buildings or buildings where new floors are being constructed.



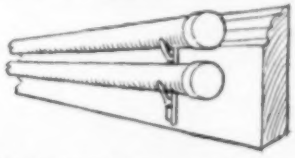
Plan view of room — Isometric view of heating cable

DIRECT ELECTRIC HEATING

(a) Unit heaters: These consist of a bank of electric heating elements fixed in a casing on which is mounted a fan which draws or blows air over the heating elements and discharges it, usually through adjustable louvres, in the required direction. A number of such units are mounted on the walls or stanchions or hung from the roof members in appropriate positions throughout the works.



(b) Infra-red heaters: These consist of heating elements usually of the sheathed metal or silica tube type mounted in a polished reflector. They operate at temperatures from 700 to 900°C, and give off the greater part of their heat output by radiation. They are mounted overhead in a similar way to unit heaters and are particularly useful for providing local areas of comfort in spaces not otherwise heated.

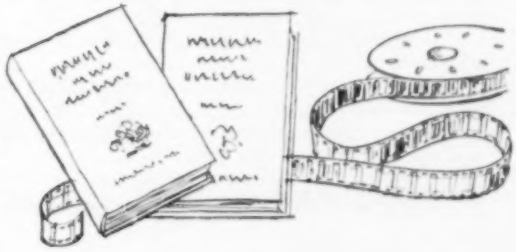


(c) Tubular heaters: These, as the name suggests, take the form of tubes approximately 2″ in diameter containing an electric heating element and are available in lengths from 2 to 17 ft. The normal loading is 60 watts per foot run and the surface temperature is from 180 to 200°F. They are usually placed round the walls at skirting level, but also can be used at high level in order to prevent downdraughts from windows and skylights.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on the industrial and commercial uses of electricity and reprints of articles and papers are available.

E.D.A. have available on free loan in the U.K. a series of films on the industrial uses of electricity. Film and Book Catalogues and Publications List sent on request.



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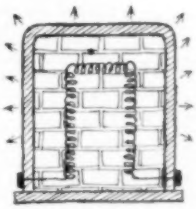
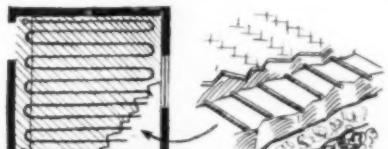
(b) Block storage heaters: These heaters consist essentially of a number of firebrick blocks which are heated up during the 'off peak' hours by means of suitable electric heating elements. The storage heaters are clad with a layer of suitable heat-insulating material and are housed in a sheet metal casing, the design being such that the stored heat is gradually dissipated throughout the day by means of radiation and convection from the casing. The great advantage of this method is that these heaters can easily be installed in existing buildings.



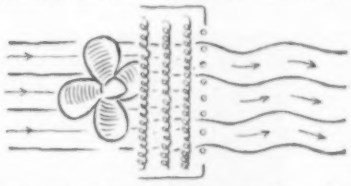
(c) Floor warming: In an 'off peak' floor warming installation, electric heating cables or ducts housing withdrawable cables are embedded in the concrete floor of the building. The cables are switched on and the floor is heated up during the 'off peak' hours, and the mass of concrete and screed of the finished floor has sufficient thermal storage capacity to heat the building during the period when current is not available. This method is only applicable to new buildings or buildings where new floors are being constructed.



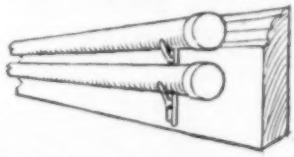
Plan view of room — Isometric view of heating cable

DIRECT ELECTRIC HEATING

(a) Unit heaters: These consist of a bank of electric heating elements fixed in a casing on which is mounted a fan which draws or blows air over the heating elements and discharges it, usually through adjustable louvres, in the required direction. A number of such units are mounted on the walls or stanchions or hung from the roof members in appropriate positions throughout the works.



(b) Infra-red heaters: These consist of heating elements usually of the sheathed metal or silica tube type mounted in a polished reflector. They operate at temperatures from 700 to 900°C, and give off the greater part of their heat output by radiation. They are mounted overhead in a similar way to unit heaters and are particularly useful for providing local areas of comfort in spaces not otherwise heated.



(c) Tubular heaters: These, as the name suggests, take the form of tubes approximately 2" in diameter containing an electric heating element and are available in lengths from 2 to 17 ft. The normal loading is 60 watts per foot run and the surface temperature is from 180 to 200°F. They are usually placed round the walls at skirting level, but also can be used at high level in order to prevent downdraughts from windows and skylights.

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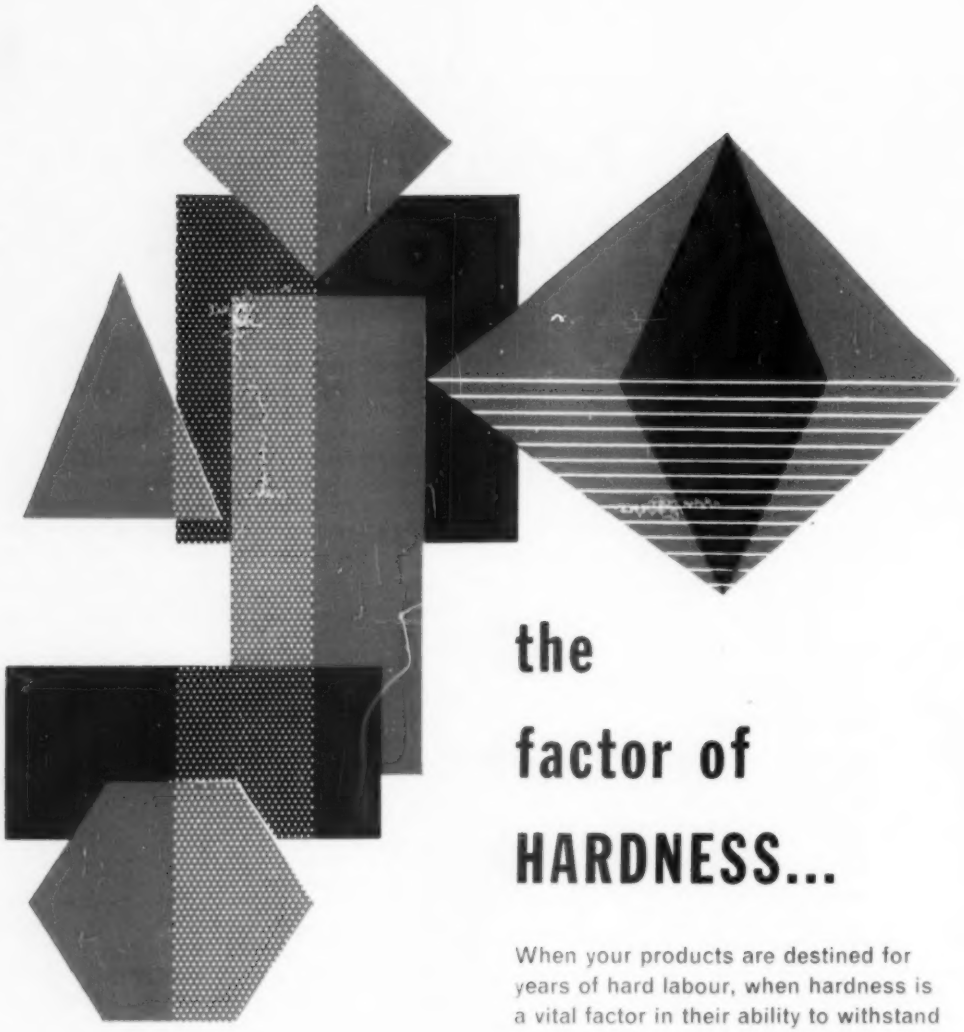

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LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS
DECEMBER, 1961 Vol. LXIV, No. 386

Determination of Copper and Lead in Aluminium Alloys Containing Bismuth

By W. Stross, G. Stross, J. Clark and D. Lush
(*International Alloys, Ltd.*)

Bismuth interferes with the polarographic determination of lead and with the electrolytic determination of copper. Referee methods avoiding such interference are too time-consuming for routine purposes. Ways of overcoming these difficulties are described.

VARIOUS bismuth-containing (free-machining) aluminium alloys are coming into use on an increasing scale. They usually contain between 4 and 6% of copper (with sometimes very close specification limits) and approximately 0·5% each of bismuth and lead. The determination of bismuth and lead in these concentrations offers in general few problems, as simple and rapid methods are available, e.g. the photometric thiourea method for bismuth[1,2] with which neither the copper nor the lead interferes, and the polarographic method for lead[2,3] in which, however, the bismuth causes some interference. At the *p*H of approximately 3, necessary for the simultaneous quantitative precipitation of the copper and reduction of the iron by the combined action of thiocyanate and hydroxylamine, bismuth hydrolyses and some lead is co-precipitated and lost, causing low results.

Determination of Lead in the Presence of Bismuth

This interference of bismuth can be prevented by the addition of tartrate. After the initial attack and dissolution of the copper, carried out as described[2,3] add 2 ml. of 2M sodium tartrate solution*, and continue in the usual way. The sodium salt is preferred to the more usual Rochelle salt because, according to the literature[4], acidic tartrate solutions should not contain potassium because of the insolubility of the acid potassium tartrate. This tartrate addition alters slightly the overall electrolyte concentration and has a slight tendency to reduce the height of the lead wave.† This is compensated by using for the calibration a standard solution (or sample) to which the same quantity of tartrate has been added. The bismuth wave (which precedes the lead wave) has, at least under our working conditions, a poorly defined beginning, so that the simultaneous determination of bismuth and lead is not possible. If much more bismuth than lead were present, the bismuth wave would interfere, but with the equal quantities of lead and bismuth present no difficulty arises without resorting to separations or to differential or derivative polarography.

* According to personal communication of their so far unpublished work, which we take pleasure in acknowleiging, the Research Laboratory of the British Aluminium Co., Ltd. are making the same use of the tartrate but are able, with more elaborate polarographic equipment, to carry out a determination of bismuth as well as of lead in the same solution.

† Recent experiments, carried out after this paper went to print, seem to show that with increasing quantities of bismuth the height of the lead wave tends to decrease slightly. It seems, therefore, advisable to evaluate the polarograms, until this phenomenon is thoroughly investigated, by either using standard solutions with closely similar bismuth contents or, better still, by the system of standard addition of lead to the sample under test and calculating from the resulting increase of the lead wave.

Determination of Copper in the Presence of Bismuth

The Problem

Bismuth may cause difficulties in the copper determination, which vary according to the method used. Of the numerous methods available for copper determination, the most useful ones for routine purposes are, in our opinion, in the order of their practical usefulness: (*a*) the photometric sodium diethyldithiocarbamate method[2]; (*b*) the electrolytic method[5,7b]; and (*c*) the volumetric method[6a,7a].

Photometric Method

Bismuth in the quantities in question interferes slightly with the photometric method, partly by turbidity and partly by a light absorption which is comparatively small, and which can often be reduced to negligible proportions by corrections, the addition of more reagent, or the use of a suitable wavelength[8a]. We find, however, that in general the accuracy and precision of the photometric method becomes inferior to that of the electrolytic method at levels from about 3·5% upwards. With care, results are usually acceptable up to about 4·5%, and very often reasonable even at the 8–10% level. The aliquot of sample used becomes, however, so small that the high multiplication factor involved makes the results less acceptable for specifications with narrow limits.

Precision photometric methods in which the light absorption is measured, not against water, but against copper standard solutions, of a concentration not very different from that of the sample under test should improve the results. However, with the Spekker Absorptiometer on which most of our tests are done, the solutions then become so dark that the sensitivity of the

barrier photocells used is not sufficient, and the improvement achieved is small. If great accuracy is desired, we therefore favour the use of the electrolytic method for contents above about 4%.

In view of the foregoing, it seemed desirable to have also available in the case of the bismuth-containing alloys—particularly for doubtful cases or check purposes—another relatively rapid and simple method reaching or at least approaching referee method standard.

Electrolytic Method

Unfortunately the electrolytic method suffers from strong bismuth interference, as the major part of the bismuth deposits on the cathode with the copper. Some of the bismuth, however, tends to deposit on the anode as a higher oxide. It is therefore not possible to determine as a first step the exact sum of bismuth and copper by determining the weight increase of the cathode (particularly as the deposit of bismuth on the cathode is rarely metallic, but usually very dark or even black, indicating oxidation or co-deposition of impurities). In the literature, statements[5–10] are found that the deposition on the anode can be prevented by adding hydrazine or urea or hydrochloric-acid/hydrogen-peroxide. We found, however, that in spite of such additions, some bismuth was invariably found on the anode, although the quantity is reduced by these additions and may become practically negligible. Hydrazine seems to be more effective in this respect than urea; in even moderately effective concentrations, however, it seems to interfere with the anodic deposition of the lead.

The A.S.T.M. electrolytic method[7b] prescribes, therefore, the separation of bismuth prior to electrolysis by precipitating it as the oxychloride. This is a tedious procedure, although it has the advantage that the precipitate can be used directly for the gravimetric determination of bismuth. The determination of bismuth by the photometric method[1,2] is, however, so simple and reliable that the procedure [7b] does not seem attractive for routine purposes.

Electrolysis with sufficiently close control of the cathode potential should permit the separate determination of the copper as well as the bismuth. The instruments necessary for automatic operation are, however, complicated and costly and, moreover, usually permit only the determination of one sample at a time, which makes them less suitable for large scale routine than the conventional multihead electrolysis assemblies.

Volumetric Method

A volumetric (iodometric) method is proposed by the British Standards Institution as the referee method for copper determination[6a] and is also described elsewhere[7a]. Bismuth does not interfere but the method suffers from the disadvantage that it requires the separation of the copper as the sulphide, and this has to be filtered off, dried, ignited and re-dissolved before the final titration. The results are very good and the iodometric end point is excellent, but the procedure becomes long-winded. In addition, we try to avoid the large scale use of sulphide separations wherever possible.

Ginsberg[11] has published a rapid volumetric method without separations, which, although using an iodometric finish, has only a moderately good endpoint; in the presence of bismuth, it becomes so poor as to be practically indistinguishable.

The attempt[2] at a short-cut in the volumetric method by separating the copper from the aluminium and silicon by sodium hydroxide attack and filtration, dissolving the insoluble fraction with acid, complexing the iron with fluoride and then titrating this solution iodometrically, involves, in our more recent experience, the risk of occasional low results, probably through some copper going into solution, leading to occasional small copper losses in the first filtration. It is intended, however, to attempt to re-define conditions under which this can be avoided with certainty, as this would then probably be a rapid and precise method.

FURTHER WORK ON ELECTROLYTIC METHOD

Theoretical.—In view of these considerations, it seemed worth while to try and work out a method for determining copper electrolytically without having to resort to separation of the bismuth. As the alloys in question mostly contain equal quantities (of the order of 0·5%) of lead and bismuth, it was felt that if a method could be found to deposit copper and bismuth quantitively on the cathode, this could easily lead to a time-saving combination of the determination of copper and bismuth with the determination of lead, which in quantities above the mere impurity level deposits sufficiently well on the anode to allow its determination without much extra expenditure of time, so that this might be advantageous in spite of the fact that the polarographic determination of lead is rapid.

If then the bismuth deposited on the cathode could be determined separately, it would be possible to subtract this from the sum of bismuth and copper. It is not generally considered desirable to obtain results by difference, but in view of the very much larger amount of copper, even an error of the bismuth determination by as much as 10% would have only a negligible effect on the copper result. In view of what was said, in the section headed THE PROBLEM, about the distribution of bismuth during electrolysis, the bismuth thus found would possibly only serve as a correction in order to obtain the copper result, without replacing a separate determination of bismuth in the alloy.

Experimental.—It was intended first to strip the weighed cathode and to titrate the bismuth in this solution with EDTA. Statements in the literature[12,13] about the techniques for the EDTA titration of bismuth in the presence of copper are somewhat controversial. The use of the very specific pyrocetechol violet as metallochromic indicator seemed particularly promising, as it enables the precise direct titration of bismuth in the presence of much lead (e.g. in 50% bismuth-lead hardeners, following closely the technique described for bismuth carbonate in the British Pharmaceutical Codex, 1959, p. 95). It was found, however, that the non-interference on copper in this titration does not extend to the unfavourable ratios of copper to bismuth found in the alloys in question (say up to 16 : 1), but rather more to opposite ratios of say 1 : 16*.

It was then decided to try to electrolyse, to strip the weighed cathode with nitric acid and make up the solution to a round volume, to determine the bismuth photometrically in an aliquot of this liquid (copper causing no interference) and to subtract the bismuth so

* From a personal communication of Dr. K. C. Braun, Chief Chemist of The American Smelting and Refining Co., South Plainfield, N.J., U.S.A., to whom we are very indebted for his interest, it appears that even in such extreme ratios of copper to bismuth exact titration by EDTA is possible, but apparently requires very accurate control of the *p*H, i.e. individual adjustment of each sample using a *p*H meter, and this again would have made the procedure unsuitable for our routine. This idea was therefore abandoned.

obtained from the weight increase of the cathode. The results were, however, disappointingly inconsistent, and on synthetic samples (high purity Al + Bi + Cu + Pb as salts, or standards with known copper content with additions of bismuth and lead) the copper results were often substantially too low.

Giving up hope of being able to determine more than one element in one operation, it was then decided to strip the cathode with nitric acid and to determine the copper in this solution by direct iodometric titration, as we confirmed that bismuth did not interfere with the direct iodometric copper determination, in spite of statements in the literature to the contrary[14]. Disappointing results were, however, again obtained.

In the absence of bismuth the titration of the copper stripped from the electrode gave exactly the same result as the weight increase of the cathode; in the presence of bismuth, however, the results were inconsistent, i.e. sometimes correct but mostly too low. Incomplete deposition of the copper was suspected, but the missing copper could not be found by examining the electrolyte by the (much more sensitive) photometric method. Usually considerably less than 0·02% copper, in respect of the weight of sample taken, was found, whilst the copper deficit was much greater—sometimes of the order of 0·4% or more.

The cause of the unexpected deficit was eventually found in the quality of the deposit formed in the presence of bismuth. It was thought at first that the mostly very dark and sometimes, on the surface, powdery deposit originated from partly oxidised bismuth depositing more or less on top of the normal copper deposit. In fact, however, it also contains some copper in the poorly adhering part. When washing the electrodes in the most usual way, i.e. by quickly replacing, without interrupting the current, the beaker containing the electrolyte by a beaker containing water, some of the deposit is easily detached, falls into the washing water and so is lost, even if great care is taken in the washing operation. In one such test 0·44% of copper was recovered from the washing water.

The following procedure was then found to give consistently correct results on synthetic samples made by (*a*) dissolving super-pure aluminium and adding known quantities of standard solutions of bismuth, lead and copper; and (*b*) dissolving standard alloy samples of known copper content and adding known quantities of standard solutions of bismuth and lead. Consistent results were also obtained on production samples of free-machining alloy containing copper, bismuth and lead.

Recommended Method

Solutions Required

(1) *Standard Copper Solution.*—Dissolve 5·000 g. of high purity copper in 40 ml. of 1 : 1 nitric acid, adding some water as necessary, boil off nitrous fumes and make up to 250 ml.

(2) *Sodium Hydroxide Solution* (approximately 9·3 N).—Add 1 litre of water to 400 g. of sodium hydroxide and dissolve.

(3) *Sulphuric Acid.*—Dilute conc. acid (sp. gr. 1·84) 1 : 1 with the usual precautions.

(4) *Nitric Acid.*—Dilute conc. acid (sp. gr. 1·42) 1 : 1.

(5) *Urea Solution* (aqueous, 40% w/v).

(6) *Potassium Iodide Solution* (aqueous, 50% w/v).—Renew as soon as free iodine appears.

(7) *Potassium or Ammonium Thiocyanate Solution* (aqueous, 50% w/v).

(8) *Sodium Thiosulphate Solution* (N/10).—Dissolve 50 g. of the crystals in water freed from CO_2 by boiling and rapid cooling. Add 0·2 g. anydrous sodium carbonate and make up to 2 litres with the CO_2-free water. If prepared in this way the solution is fairly stable, can be standardised at once, and needs only infrequent re-standardisation.

(9) *Solution of Soluble Starch* (aqueous, 5% w/v).—Prepare freshly or make stable by boiling the starch, not in water, but in saturated sodium chloride solution.

Procedure

Attack 1 g. of sample in a beaker suitable for electrolysis with 10 ml. of the sodium hydroxide solution and cover, allowing samples with high silicon content to stand for about 20 minutes on the side of the hotplate. Complete the attack by washing down the sides of the beaker and boiling. Cool somewhat and acidify with 15 ml. of the diluted sulphuric and 15 ml. of concentrated nitric acid, stirring, diluting with water and warming as necessary to obtain a clear solution. Cool and dilute sufficiently to cover the platinum gauze electrodes (i.e. usually to 175–200 ml.). Electrolyse with vigorous stirring to complete deposition of the copper (usually about 45 minutes). Without disconnecting the current replace the beaker quickly, *without washing*, by an empty beaker, then disconnect the electrodes, leaving only the cathode in the empty beaker. Strip the cathode with 7 ml. of the diluted nitric acid, by adding this dropwise, e.g. from a pipette, along the surface of the electrode. Complete the stripping by inclining the beaker and rotating the electrode so that all coated parts of it come into contact with the acid. 7 ml. seems a convenient quantity although the amount does not appear to be critical. The stripping action can be greatly speeded-up by using warm acid to which, immediately prior to use, 1 or 2 pinhead-size crystals of sodium nitrite have been added, but this is not essential. The electrode is washed down into the beaker and removed. Then add 0·5 ml. of the urea solution and bring to the boil. Cool to room temperature and neutralise with the 9·3 N sodium hydroxide solution added dropwise until an appreciable permanent precipitate forms. Clear this by dropwise addition of glacial acetic acid and add 5 ml. in excess. Again this quantity does not seem to be critical[14]. Transfer into a so-called "iodine flask" and again cool to room temperature. The volume at this stage is approximately 100–150 ml. Add 6 ml. of the potassium iodide solution (or 3 g. of potassium iodide crystals), stopper the flask, and stand for about 3 minutes. Titrate with the thiosulphate solution until the colour becomes light yellow. Add a few drops of starch and continue the titration until the starch colour shows definite signs of becoming lighter blue. Add 3 ml. of the thiocyanate solution. This releases the small amount of iodine usually absorbed by the cuprous precipitate and the blue colour becomes darker again. Complete the titration: the colour change is very sharp (within a fraction of a drop) and shows no tendency to revert. The cuprous iodide precipitate is creamy white in the absence of bismuth but strongly yellow in its

TABLE I.—TYPICAL RESULTS OBTAINED BY RECOMMENDED PROCEDURE.

Nature of Sample		Copper Expected (%)	Copper Found (%)
Base	Additions (as solutions)		
1 g. B.C.S.* 216	0·50% Pb 0·48% Bi	4·42	4·42
1 g. B.C.S. 216	0·50% Pb 0·48% Bi	4·42	4·42
1 g. B.C.S. 216	0·50% Pb 0·48% Bi + 4·0% Cu	8·42	8·38
1 g. B.C.S. 216	0·50% Pb 0·48% Bi + 4·0% Cu	8·42	8·46
1 g. B.C.S. 216	0·50% Pb 0·48% Bi	4·42	4·38
1 g. B.C.S. 216	0·50% Pb 0·48% Bi	4·42	4·45

* B.C.S. = British Chemical Standard (Bureau of Analysed Samples Ltd.).

presence, without any detriment to the sharpness of the endpoint.

It is recommended to follow the details of the above description rather closely.

Standardise the thiosulphate solution by diluting in an " iodine flask " a suitable volume of the copper standard solution with about 100 ml. of water, adding 7 ml. of the dilute nitric acid and continuing as from the words " Add 0·5 ml. of the urea solution " above.

Results and Conclusions

Table I contains a few typical results obtained by this procedure. The method cannot be called a rapid one in the strictest sense because of the time required for the electrolysis, but the actual working time is not great, particularly as the electrodes have not to be dried and weighed. The method could probably be speeded-up considerably by using one of the rapid methods of electrolysis with higher current density. It is, however, suitable for routine operation even with the conventional electrolysis machines.

Acknowledgment

These experiments were carried out in the Laboratory of International Alloys, Ltd., Haydon Hill, Aylesbury, and the authors wish to thank the directors of the company for permission to publish.

REFERENCES.

1 Bartram, J. H., and Kent, P. J., *Light Metals*, 1946, **9**, 229.
2 Committee of Chemists convened by ALAR, " Modern Methods for the Analysis of Aluminium Alloys," 1949, Chapman and Hall, Ltd.
3 Stross, W., METALLURGIA, 1947, **37**, 49.
4 Milner, G. W. C., " The Principles and Applications of Polarography," 1957, Longmans, Green and Co., Ltd.
5 Sloviter, H. A., *Ind. Eng. Chem., Anal. Ed.*, 1941, **13**, 235.
6 British Standards Institution, " Methods for the Analysis of Aluminium and Aluminium Alloys " : (*a*) B.S.1728, Part 1, 1951 ; (*b*) B.S.1728, Part 5, 1953, p. 8, Note 2.
7 " 1956 Book of A.S.T.M. Methods for the Chemical Analysis of Metals," American Society for Testing Materials, Philadelphia : (*a*) p. 385, (*b*) p. 383.
8 Sand, H. J. S., " Electrochemistry and Electrochemical Analysis, Vol. II," 1940, Blackie and Son, Ltd., pp. 63 and 64.
9 Cohen, A., " Rationelle Metallanalyse," Basle, 1948, Birkhäuser, p. 271.
10 Norwitz, G., *Anal. Chim. Acta*, 1951, **5**, 195.
11 Ginsberg, H., " Leichtmetallanalyse," 3rd Edition, Berlin, 1955, W. de Gruyter, p. 163.
12 (*a*) Malat, M., Suk, V., and Ryba, O., *Chem. Listy*, 1953, **48**, 203 (in Czech.) ; (*b*) the essentials of this paper are given in F. J. Welcher, " Analytical Uses of Ethylenediamine Tetra-acetic Acid," New York, 1958, v. Nostrand, p. 207 ; (*c*) Suk, V. and Malat, M., *Chemist-Analyst*, 1956, **45**, 32.
13 Cifka, J., Malat, M., and Suk, V., *Coll. Czechosl. Chem. Commun.*, 1956, **21**, 414.
14 Hillebrand, W. F., and Lundell, G. E. F., " Applied Inorganic Analysis," 2nd Edition, J. Wiley and Sons, Ltd., 1953, p. 248.

Meetings Diary

(*continued from page* 262)

January 17th

Leeds Metallurgical Society. " Developments in Powder Metallurgy," by L. HARRISON. University Staff House, University Road, Leeds. 6.30 p.m.

Manchester Metallurgical Society. " Materials for Astronautic Vehicles," PROFESSOR A. J. MURPHY. Manchester Literary and Philosophical Society, George Street, Manchester. 6.30 p.m.

West of England Metallurgical Society. " Radiation Effects in Nuclear Reactor Materials, by R. S. BARNES. (Joint meeting with the **Local Section of the Institute of Physics.**) College of Science and Technology, Ashley Down, Bristol, 7. 7 p.m.

January 18th

Liverpool Metallurgical Society, " Metallurgical Films." Department of Metallurgy, University of Liverpool, Liverpool. 7 p.m.

West of Scotland Iron and Steel Institute. " Engineering Aspects of Continuous Casting Plants," by E. BALL. (Joint meeting with **Iron and Steel Engineers' Group.**) Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2. 6.45 p.m.

January 19th

Society of Chemical Industry, Corrosion Group. " The Corrosion Behaviour of Decorative Nickel-Chromium Coatings," by G. N. FLINT. Society of Chemical Industry, 14, Belgrave Square, London, S.W.1. 6 p.m.

January 23rd

Institution of Plant Engineers, South Wales Branch. " Refractory Brickwork for Boilers and Furnaces," by a representative of Morgan Refractories Ltd. South Wales Institute of Engineers, Park Place, Cardiff. 7.30 p.m.

January 25th

Institute of Metals, Birmingham Local Section. " Fundamentals of Non-Destructive Testing," by J. F. HINSLEY. College of Advanced Technology, Gosta Green, Birmingham. 6.30 p.m.

Institute of Metals, Sheffield Local Section. " Grain Size and the Strength of Metals, by PROFESSOR N. J. PETCH. Applied Science Building of the University, St. George's Square, Sheffield. 7.30 p.m.

West of England Metallurgical Society. " Progress in Non-Destructive Testing," by R. S. SHARPE. College of Science and Technology, Ashley Down, Bristol 7. 7 p.m.

January 26th

Society of Chemical Industry, Corrosion Group. " Achievements and Aims in Corrosion Prevention : Afterthoughts on the International Corrosion Congress," by S. C. BRITTON. (Joint meeting with **South Wales Section.**) Technical College, Tavistock Road, Plymouth. 5.30 p.m.

Institution of Plant Engineers, Birmingham Branch. " Repairs to Heavy Iron Castings," by D. H. JONES. Imperial Hotel, Temple Street, Birmingham. 7.30 p.m.

January 30th

Institution of Mechanical Engineers, Automobile Division. Discussion: " Why Can't Metallurgists Provide the Materials Engineers Require ?" 1, Birdcage Walk, Westminster, S.W.1. 6 p.m.

January 31st

Manchester Metallurgical Society. " Metallurgical Problems of High Temperature Steam Generation," by M. G. GEMMILL. Manchester Literary and Philosophical Society, George Street, Manchester. 6.30 p.m.

ONE of the members of the Simms group of companies, Horstman, Ltd., of Bath, have placed an order with Wild-Barfield Electric Furnaces, Ltd., for the supply of high frequency induction heating equipment. The generator will be a 36 kW. model with two-station output. One station will feed a Wild-Barfield A.H.F. progressive hardening unit, which equipment will be employed for the pattern hardening of shafts. The other will be used as a general purpose station for hardening, brazing or any other application required within the scope of the equipment.

A Chemical Saw

By J. E. Palmer

Senior Experimental Assistant, G.E.C. Atomic Energy Division

The author describes equipment for cutting small samples from beryllium single crystals. A tungsten wire cathode, wetted by a phosphoric/sulphuric acid electrolyte is drawn backwards and forwards across the anode—the beryllium crystal.

DURING an investigation into the oxidation of beryllium a need arose for small samples of a beryllium single crystal. The available crystal, which was to be cut into $\frac{1}{4}$ in. lengths, was in the form of a cylinder approximately 6 in. long and $\frac{1}{4}$ in. diameter.

Conventional machining or sawing methods produce stresses which can result in recrystallisation on subsequent heat treatment and for this reason, stress-free cutting of metallic single crystals is generally carried out by chemical means. The most effective chemical method employs localised solution of the crystal by a suitable etchant which is applied on a moving thread, and several chemical saws based on this principle have been described.[1,2] Experience of a saw based on these designs proved that some modification was necessary in order to cut beryllium satisfactorily. In view of the high cost of the material wide cuts were undesirable, the cut surface was to be as smooth as possible, and it was required to cut the crystal at various angles to the longitudinal axis. In order to satisfy these requirements it was important that the thread should be located accurately in the cutting plane, i.e. that plane described by the thread during cutting, and that delivery of etchant on to the thread should be controlled.

Preliminary Work

The problems of location and feed were solved by locating the thread in two slots, one on each side of the crystal. A controlled amount of etchant was then allowed to enter the slots and was transferred to the crystal by the thread. This device therefore dispensed with the elaborate systems of pulleys described by other workers.[1,2,3]

Initially, a thread of polyvinylidene chloride was used with etchants of HF, HCl and H_2SO_4 in various concentrations. The surfaces produced were rough and uneven, the cutting action was slow, and the thread stretched and frayed until it finally snapped. In order to increase the rate of cutting electrolytic means were employed necessitating the use of a metallic thread which became the cathode. Copper, platinum, stainless steel and tungsten wires of various sizes were used, and of these tungsten wire of 0·008 in. diameter proved the most successful. The etchant employed was a development of an electropolishing solution[4] and consisted of three parts H_3PO_4 to one part each of H_2SO_4 and distilled water.

Description

A diagram of the apparatus is shown in Fig. 1 and a photograph in Fig. 2. The saw is mounted on a small Dexion frame and is constructed from Perspex, with the exception of the nuts and bolts which are of stainless steel.

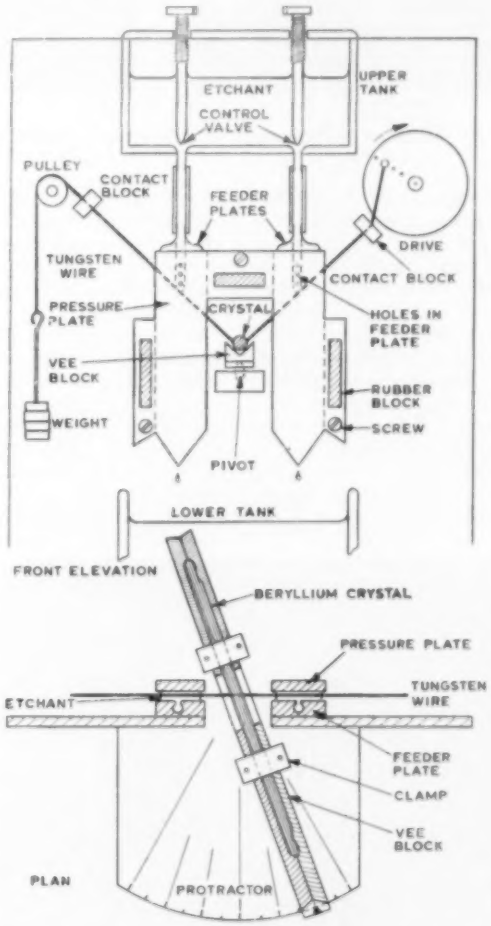


Fig. 1.—Diagram of the apparatus.

The beryllium crystal is clamped in a vee-block which is pivoted in the cutting plane. The angle of incidence to the plane can be varied through 60°, and the exact angle required is set by means of a protractor. The tungsten wire passes beneath the crystal and is located in a slot on each side of the specimen. Each slot consists of a feeder plate through which acid is delivered and a pressure plate which is positioned by three screws acting against rubber blocks to vary the width of the slot. In practice, when the slots are adjusted to be a close fit on the wire, surface tension causes them to be filled with acid. Etchant from the upper tank feeds the

Fig. 3.—Surfaces of three typical cuts from a beryllium crystal. Bright field. × 7 (approx.)

slots through P.V.C. tubing and the flow is controlled by two Perspex needle valves. After leaving the slots the etchant drips into the lower tank, and this is scavenged by a small air lift pump, constructed from glass tubing, which returns the etchant to the upper tank in order that the saw can run continuously without attention.

The wire, driven by an eccentric drive from an electric motor, reciprocates at 16 passes per minute, and its tension is maintained by passing one end over a pulley and attaching a small weight. The radius of the eccentric drive can be varied to alter the length of reciprocating wire, and hence its speed. Electrical contact with the wire is provided by passing it through small holes in two copper blocks. A D.C. supply is obtained from a 2 volt accumulator, the positive terminal being connected to the crystal and the negative to the copper blocks. A current of approximately 2 amps. is maintained throughout the cutting period.

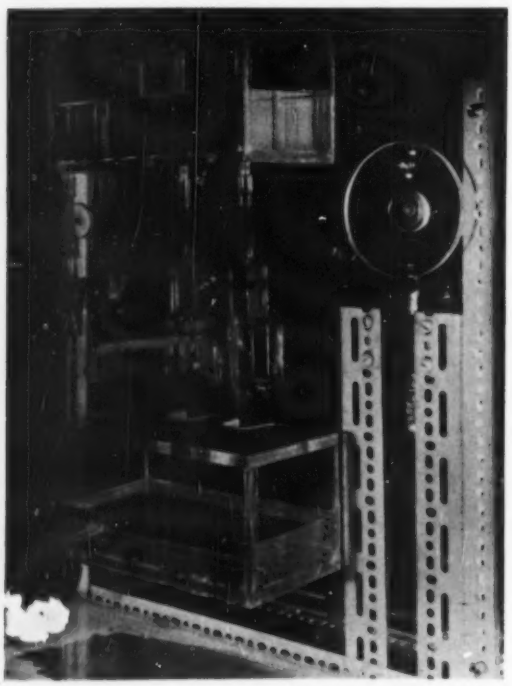


Fig. 2.—General view of the chemical saw.

Operation

The chemical saw described in the previous section has been in use for several months, during which time eleven samples have been cut from the $\frac{1}{4}$ in. diameter beryllium crystal. In each case the samples have been about $\frac{1}{4}$ in. long and this small piece has been gripped in a collet to ensure that it remained in the vee block at the completion of the cut.

The surfaces of three typical cuts are shown at an approximate magnification of × 7 in Fig. 3. It was found that the best surfaces were produced by continuous operation of the saw, and that interruption invariably caused a ridge on the cut surface. The cutting operations take 20–30 hours to complete, one tungsten wire being used for each cut.

The saw has only been used for cutting beryllium to date, but there seems no reason why other metals should not be cut providing that a suitable etchant is selected.

REFERENCES

1 Maddin, R. and Asher, W. R., *Rev. Sci. Inst.*, **21**, 10 (1950).
2 Yamamoto, M. and Watanabe, J., *J. Japan Inst. Metals*, **19**, 38 (1955). English translation: 859th Report of Research Inst. for Iron and Steel.
3 M. Metzger *Rev. Sci. Inst.* **29**, 7 (1958).
4 "The Metal Beryllium," White, D. W. and Burke J. E. The American Society for Metals, 1955. Page 508.

6 MeV X-ray Equipment for E.S.C.

English Steel Corporation, Ltd., Sheffield, has been supplied with a 6 million volt X-radiographic unit by Vickers Research, Ltd. This addition to the non-destructive testing equipment incorporates a 6 MeV sealed-off linear electron accelerator, and will be used by E.S.C. and its subsidiaries for the examination of steel of thicknesses up to 12 in. Because the unit is compact and easily manoeuvreable, the range of products which can be inspected is very extensive. The time taken to examine steel products by means of this unit is considerably reduced below that taken when radioactive isotopes are used, and the definition is much improved because of the much smaller size of the X-ray source. English Steel Corporation, Ltd., is the first steel company in the U.K. to introduce a linear electron accelerator for the examination of steel castings and weldments made from forgings or castings.

Method of Standardisation in Ultrasonic Flaw Detection

By D. J. Hayes, B.Sc., A.Inst.P.

*U.K. Atomic Energy Authority, Research and Development Branch, Springfields Works**

A method of standardisation suitable for more general adoption in ultrasonic inspection is described, in which a cylindrical hole is used as an artificial flaw. The resolution and sensitivity may be specified in terms of a hole of a particular size, located specifically with respect to the material surface. The material supplier can then choose the technique and degree of mechanisation best suited to his needs.

IN radiography the use of penetrameters is generally accepted. They enable a specified level of sensitivity to be reproduced with different equipment, but they are not without their limitations. The penetrameter may be described as an artificial flaw, and it is well-known that the relationship between artificial flaw sensitivity and sensitivity to natural defects is a loose one. Moreover, there are several kinds of penetrameters in use, and since they differ in performance the type of penetrameter to be used must be specified.

No corresponding technique for standardisation is in general use in ultrasonic inspection. As a result it is necessary to define closely inspection techniques for particular cases, often to the extent of specifying a particular model of ultrasonic testing unit. This practice has obvious disadvantages.

This article describes a method of standardisation in ultrasonic inspection suitable for general adoption. A close analogy to the use of radiographic penetrameters exists, in that a choice of artificial flaw is available and a sensitivity level in terms of natural defect size cannot be defined. Within these limitations it is shown that ultrasonic sensitivity levels may be defined in a way suitable for general application.

Standardisation

The principle adopted is essentially that of the radiographic penetrameter, namely that at any point in the material under inspection the sensitivity in terms of an artificial flaw should not be less than a given level. Corresponding to the penetrameter, a suitable artificial flaw is required. Because of the point-to-point variations in field strengths of ultrasonic transducers and the variations in field patterns with probe type and dimensions, surface contour of the material under test, frequency, etc., the artificial flaw must be capable of being put into a test sample of the material to be inspected. Thus, for this application, the use of the thin plate or the ball-bearing to provide a sensitivity level cannot be recommended. More satisfactory alternatives are the flat-bottom hole and the cylindrical hole.

In general, radiographic penetrameters can be made in a range which extends to the highest sensitivities required. Unfortunately it is not possible to cover the full range of sensitivity in ultrasonic testing by the use of either cylindrical or flat-bottom holes. The smallest of either of these which can be made gives too large a signal, and hence does not specify a sufficiently high level of sensitivity for some requirements. A standard means of scaling down signals from the artificial flaw is therefore necessary. A suitable method is available in the matched calibrated attenuator, which provides a convenient means for comparing amplitudes. The unit is the decibel; the ratio of two amplitudes A_1, A_2 in decibels is $20 \log_{10} \frac{A_1}{A_2}$. This equipment is now available for the majority of commercial ultrasonic units.

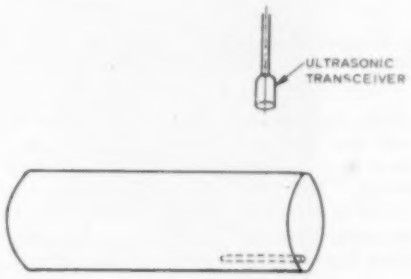


Fig. 1.—The cylindrical hole as an artificial flaw for sensitivity calibration in ultrasonic testing.

Selection of Artificial Flaw

The flat-bottom hole is widely used in the U.S.A. and nationally-recognised standard test blocks are available. Sub-standards are expensive and cannot be made in the non-specialised machine shop. The cylindrical hole is a possible alternative. The hole is larger than the length of the detector in the direction parallel to the hole axis, and it lies normal to the direction of the ultrasonic beam. (Fig. 1.) In either case, used in conjunction with a calibrated amplifier, the artificial flaw need not be very small. $\frac{1}{16}$ in. diameter has been found suitable for the cylindrical hole, and this can be made in the non-specialised machine shop.

The Cylindrical Hole as an Artificial Flaw

The cylindrical hole specifies a line sensitivity rather than sensitivity at a point. It is therefore particularly suited to material having cylinder-like defects, i.e. extruded and rolled bar stock, for the inspection of which the ultrasonic method is particularly suited.

In general, the field strength of the transmitting probe is greatest along its axis and falls away off the axis at a rate which can vary between wide limits. The concept of sensitivity per unit length must therefore be used with caution. In regions where the field is essentially flat the smallest diameter defects—those at the rejection limit—of length less than that of the detector would not be detected. Thus the maximum detector length which can be used for a particular sensitivity specification is limited to the maximum length of the smallest diameter

*Mr. Hayes is now at the C.E.G.B. Berkeley Nuclear Laboratories.

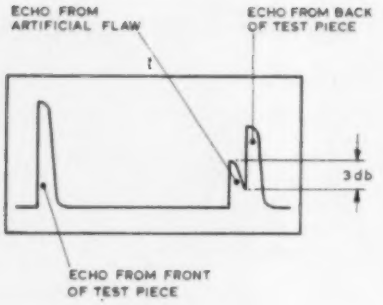


Fig. 2.—Oscilloscope trace of signals from test piece showing method of defining resolution.

defect which can be allowed to go undetected. This length will also determine the scanning pitch. Larger probes may be used, in which case the sensitivity must be increased. The best method for determining the extent of this increase is by experiment for the particular case. Scanning speed and pitch for conventional immersion testing has been discussed by Krautkrämer.[1]

Resolution

Whichever artificial flaw is used the resolution of the test must be specified. This is necessary since, because of the finite length of the pulse, and in some cases for other reasons, sensitivity drops near the metal surface. Resolution may be specified in terms of the small distance between artificial flaw and metal surface at which the artificial flaw may be resolved. The term "resolved" may be defined as a difference of 3 db (say) between artificial flaw signal peak and its conjunction with the interface echo. (Fig. 2.)

Frequency

The specification of resolution limits the lowest frequency which may be used, since resolution depends on pulse length which, for a given number of cycles, is inversely proportional to frequency. It might be anticipated, however, that the rate of change of signal amplitude with defect size would vary with frequency, with the higher frequencies giving larger relative signals than the lower. Some evidence has been obtained to show that this is not the case for cylindrical defects at least. Fig. 3 gives plots of relative signal amplitudes from cylindrical holes of various diameters at two frequencies under the same conditions, and the slope of the lines are identical within the experimental error. In each case the holes were 1 in. below the surface of the test block and immersion testing conditions were used. The frequency of a pulse actually covers a band of frequencies, and the band width increases as the number of cycles in the pulse decreases, so that frequency cannot be specified independently of pulse length. For these reasons it is doubtful if any useful purpose is served by including the frequency in the specification—at least in the case of cylindrical defects.

Application and Advantages

An example of the application of this method of specifying ultrasonic sensitivity would be: the material is to be inspected ultrasonically at a sensitivity of not

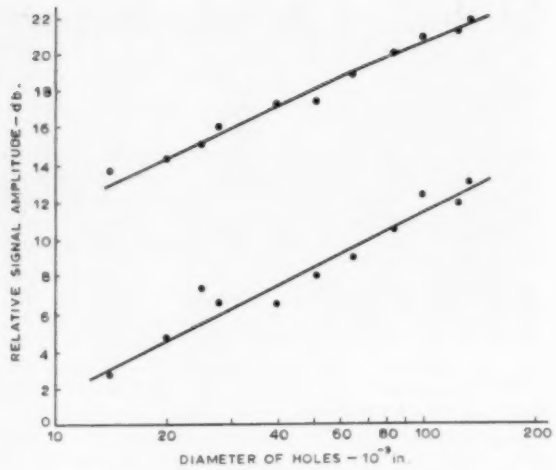


Fig. 3.—Relative signal amplitudes from cylindrical holes at two frequencies. A 14mm. diameter barium titanate transceiver was used at each frequency. The couplant was a 1 in. column of water, and the 1 in. long holes were 1 in. below and parallel to the surface of a flat-topped magnesium block. Signal amplitudes given are relative to an arbitrary zero.

less than + 12 db with respect to the signal from a $\frac{1}{16}$ in. diameter hole using transducers not greater than $\frac{1}{2}$ in. diameter; the resolution of the signal from this hole situated $\frac{1}{8}$ in. from the surface of the material is to be not less than 3 db.

This completely specifies the ultrasonic test. Any of the various techniques available or any make of ultrasonic equipment may be used—the specifier has merely to satisfy himself (*a*) that the techniques proposed by the suppliers do in fact fulfil the specification, and (*b*) that material giving rejectable signals will in fact be rejected. For the former purpose the location of the region of minimum sensitivity in the cross section of the material for each technique must be known. This is usually at the surface, in which case one test block only is required to check both resolution and sensitivity. The test block would be a section of the material containing a $\frac{1}{16}$ in. diameter hole greater than $\frac{1}{4}$ in. long and situated $\frac{1}{8}$ in. from the surface. If there is any doubt about the position of minimum sensitivity in any technique, it is a simple matter to make a series of test blocks and check the variation in sensitivity across the material section.

An important feature of an ultrasonic testing specification in this form is that it gives the supplier a free hand to select the technique and degree of mechanisation best suited to his needs. Different suppliers may choose to use different equipment and techniques to apply the same specification. Moreover, with a specification in these terms, the equipment manufacturer will be encouraged to develop—for example—probes of flat sensitivity response, or probes of increasing sensitivity with depth to compensate for the attenuation of the subject material, with their evident advantages to the supplier.

REFERENCE.

1 Krautkrämer, J.: *Solus-Schall News* No. 9, June 1958, published by Solus-Schall, Ltd., Stanmore, Middlesex.

New Assembly Wing for Cambridge Instrument Company

Current Developments on Show on Opening Day

Photo, Henk Snoek

The addition of a new instrument assembly wing to the research laboratories of the Cambridge Instrument Company provides a pleasing frontage on the Chesterton Road and River Cam.

FOUNDED in 1881 by Sir Horace Darwin, son of Sir Charles Darwin, F.R.S., the famous biologist, the Cambridge Instrument Co., Ltd., housed its original staff of seven in a small workshop in Cambridge. Today it employs some 2,000 people, and has three United Kingdom factories (in Cambridge, Muswell Hill and Finchley), two overseas manufacturing companies (in the United States and Australia), and an associated company in the United Kingdom (Electronic Instruments, Ltd.).

Some two years ago a new three-storey research block fronting Chesterton Road was opened at the Cambridge works, this being one of a number of stages in the company's expansion programme that have taken place during the last few years. Completion of the latest—the building of a new instrument assembly wing at Cambridge—was marked by the official opening on 23rd October, when Sir Keith Joseph, Bt., M.P., Minister of State at the Board of Trade, performed the ceremony.

The New Wing

Immediately obvious features of the new wing are the clean functional sweep of its two raised storeys, the ground level car-park beneath, and the harmonious way in which it blends with the research laboratories and the entrance hall, to which it has been planned as a logical architectural extension. The two raised storeys provide a working area of approximately 15,000 sq. ft. fronting on to Carlyle Road, at right angles to and behind the entrance hall, to which both are joined by connecting doors, as are the three floors of the research laboratories. At the other end of the new wing a link block containing a lift, stairs and toilet facilities connects it to other works buildings.

The two-thirds of the first floor area nearest to the entrance hall is taken up by offices, while the remainder is occupied by the microanalyser department. The whole of the second floor area is used as a workshop for instrument assembly and testing. Both these production departments are connected by air-locks to the link block containing the stairs and the lift.

Structurally, the two upper storeys consist of a box, with a reinforced concrete frame, approximately 150 ft. long and 50 ft. in depth, based on a solid concrete slab supported by two rows of cylindrical columns from which the slab cantilevers out about 8 ft. front and back. The windows are double-glazed and the infill panels below them are faced with golden-buff bricks. The air supplied throughout the building is conditioned and filtered. Essential services—ventilation and heating inlets, gas, compressed air, water, electrical supplies, telephone cables, etc.—are laid in horizontal floor ducts running the full length of the building below the windows, and to reduce fire risk all work-benches are wired with mineral-insulated metal-sheathed conductors. Two penthouses on the roof contain the air-conditioning plant.

Conditions in the new instrument assembly wing are ideal—its modern decor and air-conditioning producing pleasant and comfortable surroundings in which to work. Additionally, the dust-free atmosphere simplifies the

The test room and galvanometer mounting department on the second floor of the new wing.

manufacture of precision instrument movements which must be kept scrupulously clean.

Current Research and Development Work

The additional 15,000 sq. ft. of production space provided by the new wing has already begun to play its part in enabling the company to exploit more fully—in practical manufacturing terms—the growing potential offered by the intensive research and development work now in progress. An example of this is the Microscan X-ray analyser, whose rate of production is expected to double itself within the next few months. This instrument, which is used for investigating the microstructure of metals and minerals, was partly responsible for the record export turnover achieved in 1960, which was 47% higher than in 1959.

Following the official opening, guests were afforded an opportunity of inspecting the new wing and of touring other production departments and the research laboratories. In addition to research and development work on new instruments and improved versions of existing ones, many of the company's current range of instruments in production were to be seen. Space limitations preclude more than a brief reference to a few of the items on show concerned with chemical analysis and the microstructural study of metals.

X-Ray Microanalysis

Research and development work on X-ray microanalysis and allied techniques is continuous, and, where necessary, the standard Cambridge Microscan X-ray analyser is being modified or supplemented in order to increase its versatility.

The need for slow scan rates—down to one micron a minute—has been established by Dr. D. A. Melford of Tube Investments Research Laboratories, and other workers. This has resulted in the development of a slow-scan generator capable of causing the Microscan probe to scan at this speed. It is a separate unit that can be used either to generate an ultra-slow single line scan or to produce a slow raster in conjunction with the existing Microscan line time-base circuit, and very little modification to existing Microscan analysers is necessary before a generator can be fitted.

Experimental work is also directed at a method of extending the range of the instrument down to low atomic numbers. In addition, the performance of various types of EHT equipment is being assessed (work involving the development of suitable measuring techniques and the construction of specialised test equipment), and attention is being paid to the use of C.R.T. storage systems, probe current integration, and various types of spectrometer.

Experimental Scanning Reflection Electron Microscope

This microscope is being developed primarily for the examination of specimens that have comparatively rough surfaces or characteristics that preclude the use of extraction replica techniques. It is intended to be largely complementary to the transmission electron microscope, and other applications are likely to include the examination of delicate fibres and the study of voltage gradients across semi-conductor junctions and similar phenomena.

In the scanning microscope, a finely focused beam of electrons is made to scan an area on the surface of a solid specimen. The back-scatter of low energy electrons thus produced is detected by the phosphor of a scintillation counter, the output of which is amplified and used to modulate the brightness of beams scanning two cathode ray tube screens in synchronism with the electron beam scanning the specimen. The pictures thus formed on the screens provide a record of the variation in certain properties of the specimen surface. One of the screens is fitted with a camera so that the specimen can be observed and photographed simultaneously.

The new microscope utilises many of the principles investigated in some detail at the Cavendish Laboratory and the Cambridge University Engineering Department. The experimental instrument, now in course of assembly, employs several basic units of the standard Microscan X-ray analyser. Modifications to the units coupled with the addition of suitable ancillaries are expected to provide the high electron resolution required for a reflection electron microscope.

Analysis of Gases in Metals

Small amounts of gas occluded in a metal have a considerable effect upon its physical properties. Hydrogen is especially important as it frequently causes hair line cracks or embrittlement in a finished steel product. The Cambridge apparatus for the determination of hydrogen occluded in metals during melting operations is based on equipment originally designed by the British Welding Research Association. They suggested heating the metal in a stream of argon or nitrogen and analysing the resulting mixture using a katharometer. In the Cambridge apparatus the argon circulates in a closed system, the results being then obtained in a more convenient form.

The sample (up to $\frac{1}{4}$ in. in diameter and $1\frac{1}{2}$ in. long) is heated at 650° C. in a furnace which is part of the argon filled system. At another point in the circuit

is a katharometer which is connected to an indicator or recorder ; the final result is obtained after the specimen has been in the furnace for about ten minutes. The minimum full scale reading is between 20 and 100 p.p.m. by weight, depending on the type of recorder or indicator and on the weight of the specimen. This method has advantages over the estimation carried out *in vacuo*—the construction and method of operation is simpler and the time taken is shorter.

Polarography Applied to Automatic Analysis

A Cambridge Univector polarograph is used in conjunction with the automatic sampling apparatus designed and marketed by Messrs. Baird and Tatlock (London), Ltd. The Univector polarograph is not to be confused with the derivative type of polarograph, although the records it produces are superficially similar in appearance. In the Univector, an A.C. voltage is applied to a mercury dropping electrode in series with a variable D.C. voltage, the resulting record being dependent upon the A.C. impedance of the electrode.

In the B.T.L.-Cambridge equipment a sample is taken from the process stream, diluted if necessary, and the supporting electrolyte added. After the solution has been degassed with hydrogen the potential applied to the electrode is varied over an appropriate range and the A.C. polarogram is traced out on the chart of a Cambridge electronic recorder, the result appearing as a sharp peak rising from a horizontal line. The most suitable concentrations for measuring are between one and ten milligrams per litre.

The apparatus enables the process control chemist and instrument engineer to apply polarography to the automatic monitoring of processes, examination of effluents, etc. It is very sensitive and allows many substances to be measured in the presence of much larger concentrations of others which have a different reduction potential.

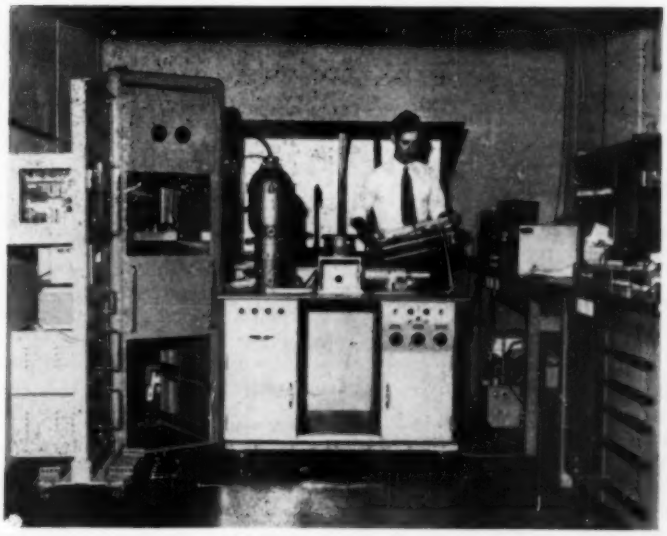
Micrometering Pump

This pump is designed to produce flow rates of the order of 0·1 ml./min. when driven by a geared motor running at 68 r.p.m. The valves are operated automatically and materials used in the construction can be chosen according to the nature of the liquid being metered. For example, one type, which has a delivery rate of 1 ml./min., is made of stainless steel and graphitic carbon and handles nitric acid solutions.

Pumps of this type, which provide an accurately known flow of a liquid, are mostly needed in work connected with the design and development of automatic analytical equipment. The company, unable to find a suitable pump elsewhere, decided to develop one for its own use, and variants of it will be available for sale to other makers of automatic analysers. The company's associates, Electronic Instruments, Ltd., have already planned to use this pump in production equipment.

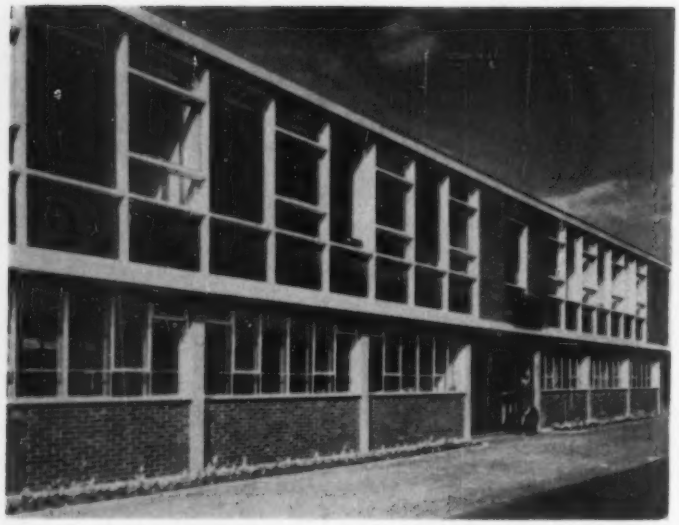
Maintaining Progress

The original range of instruments made by the company—intended for experimental purposes and for physiological research—has expanded through the years to include electrical, temperature-measuring, engineering and analytical instruments—all with research and industrial applications and comprising a range probably unsurpassed for quality and diversity. In all these fields many of the company's instruments have been commercial " firsts," and a number of important instrumental techniques—such as gas analysis by the thermal conductivity method and X-ray microanalysis—have been associated with the company's name almost from their inception. As mentioned earlier, the new wing is already beginning to play its part, and will become even more important in the future as an increasing number of new instruments spring from the work of the research laboratories.



Experimental work on an improved scanning electron microscope.

Assembling and testing a new instrument for determining gases occluded in metals.



The wire division research department building is a prestressed concrete structure using Bridon high tensile prestressing wire.

Wire and Rope Research

New Centre for British Ropes Ltd. Opened at Doncaster

ROPEMAKING is one of the oldest crafts known to man: no one knows who made the first. Hand-made ropes of many materials were used by ancient civilisations, and even the modern wire rope is antedated some 2,000 years by bronze wire ropes made by the Romans. In spite of modern research, and the thousands of years of craftsmanship on which it is based, no one has yet been able to devise a better technique for making rope than by twisting together many long strands of strong, thin, flexible material.

Before the Industrial Revolution, there were in this country many one or two-man "roperies" laboriously spinning rope by hand, but mechanisation and industrial concentration brought many of these together into larger units until, at the time of World War I, the industry was a full and live partner in British engineering. With the post-war recession, many major firms amalgamated in 1924 to form British Ropes, Ltd., and by 1927 this solidly-knit group of seven wire manufacturers, eighteen wire rope makers and seven fibre rope makers was strong enough to meet stiff outside competition.

The pooling of much of the industry's best brains and skill is one of the big factors in the present success of the group. Old tradition, go-ahead production and research techniques, ancient skills and modern technology—all these have their place in the industry, and British Ropes believe they have "hit on the right blend," which is probably why they are today the largest organisation of their kind in the world.

Three Divisions

The group comprises three divisions for the main products of wire, wire rope and fibre rope, each under the control of a general manager who is also a main board director. The divisions, while working in co-ordination, have their own production, research and selling facilities, integrated by the overall group management policy.

Wire Division.—Four factories in Britain and three overseas meet the needs of the group in a sector which has perhaps shown the biggest expansion rate of all in the industry. Much of the wire production is made into ropes by the group, and a further appreciable proportion finds its way into ropes made by firms outside the group, but a good deal of the expansion referred to above has been due to the increased use of prestressed concrete in civil engineering. The high-tensile steel wire and strand has been made the subject of special research and production capacity in the group, and new plant has been laid down to meet the ever growing demand for this universally indispensable material.

Wire Rope Division.—Wire rope is a hard-working hard-wearing piece of specialised equipment playing a vital role in modern life. Seven factories in Britain and six overseas produce all kinds of wire ropes from small steel aircraft cords to heavy mining, engineering and bridge ropes. In certain applications—notably bridge ropes—the group claims to have reached standards of manufacture far ahead of any other producer in the world. All wire ropes—almost 1,000 tons in all—for the recently opened Tamar Bridge, Plymouth, were made by British Ropes. Each suspension cable is 2,200 ft. long and $2\frac{3}{8}$ in. in diameter, and consists of 31 steel wire locked-coil ropes in each.

Fibre Division.—This division, while rooted in the old rope-making traditions, is certainly not tradition bound. Though all the usual types of fibre rope are made in four factories in Britain—hemp, manila, sisal, coir—the group was one of the world pioneers in the use of man-made fibres in ropemaking. Even newer materials are on the way; the groups research deparment and modern production techniques have transformed this ancient hand-craft into an industry as up-to-date as any.

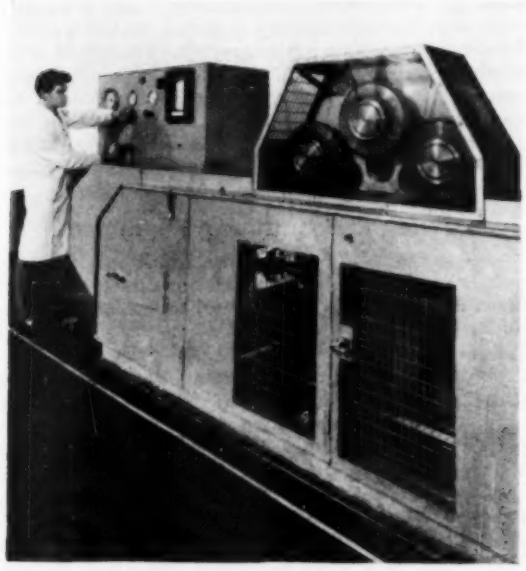
The New Research Centre

The attitude of British Ropes, Ltd., to research is summed up in a statement from the chairman, Mr. Harry Smith, in which he says: "In this present age of incredibly rapid scientific development we do, and must continue to, devote an increasing amount of effort

to investigating and utilising new materials, improving the quality and versatility of our products and developing new uses for them. Our future prosperity as a company is, therefore, essentially geared to the extent and effectiveness of our research and development resources and our magnificently equipped research centre at Doncaster symbolises our determination to maintain and improve the pre-eminent position we hold in our industry."

The research centre referred to by Mr. Smith was opened on 27th October, 1961, by Mr. Niall Macpherson, M.P., Parliamentary Secretary to the Board of Trade, who stressed the importance of research to enable industries to keep up with modern trends and with the rapidly developing needs of our time. "It is no less necessary," said Mr. Macpherson, "to enable us to remain competitive and to hold our own in world markets. In that, British Ropes, I understand, have been remarkably successful. In each of the past two years the group has exported some £5 million worth of goods from its factories in the United Kingdom. I gather that its achievement is due in no small measure to its success in reducing costs of production through increased efficiency. Direct exports amounting to one quarter of output, not to mention the large amount of production which goes into manufactures exported by other firms—that is a record of which the firm has a right to be proud."

Built and equipped in three years at a cost of nearly £200,000, the new research centre has two main divisions —wire and rope—and operates a marine testing station off the Norfolk coast. Its scientific and technical function is to find answers to problems about products of today, and to devise and develop products of tomorrow. Results determine improvements in manufacture to ensure greater safety, efficiency and life of rope and wire, or whether new materials or processes should, or should not, be put into production.



Fully hydraulic 4-ton capacity reverse bend testing machine fitted with autographic extension recorders for ropes up to $\frac{5}{8}$ in. diameter.

The Emiskop II electrio microscope in use in the wire division research department has a maximum useful magnification of about 50,000.

Wire Research Department

In the wire department investigations range from raw material through heat treatment and wire drawing to the final product. The quality of hard drawn wire is governed to some extent by the quality of the raw material—wire rods. The department is making an extensive study of the characteristics of the regular supplies of rods, particular attention being devoted to the number and type of surface defects. This is long term work, but work which, it is hoped, will result in an improvement of raw material quality.

Good heat treatment is a pre-requisite of successful wire production. While the metallurgy of plain carbon steels is fairly simple, the continuous nature of the heat treatment process used in wire production is considerably more complex than the heat treatment of individual components. Therefore, a special recording pyrometer has been developed to reveal temperature changes in material as it proceeds through the plant. With this and supplementary work in the laboratory evidence has been produced which has enabled considerable improvements to be made.

Apart from finished wire quality, the precise physical characteristics of various types of wire are of great importance, and much of the department's time is spent on the determination of, for example, fatigue strength, stress relaxation and stress/strain factors. Haigh-Robertson rotating bending machines and an Amsler Vibrophore push-pull machine are in constant use for fatigue testing. An air-conditioned room houses the equipment used for determining the stress relaxation properties of prestressed concrete wire; apparatus is available for the testing of both individual wires and strand.

Efforts are always being made to improve finished wire quality and complete metallurgical examinations of wire, both before and after service, are made from

time to time. For example, it is not uncommon for each wire taken from a length of a multi-strand rope to be examined for physical properties, metallographic structure and chemical analysis.

The department is well equipped. In addition to the apparatus already mentioned it has a range of physical testing equipment, including bend test and torsion test machines and numerous tensile testing machines. Among the latter is an Instron machine which is based on the new strain gauge cell weighing system; this enables the stress/strain properties of wire to be determined with unsurpassed speed and accuracy.

As the production of high tensile steel wire becomes more developed, the internal micro-structure of the metal increases in importance. The limits of discernment of the light microscope have been reached and it is considered that only by the use of the electron microscope can further advances in the technology of wire production be made. Accordingly, British Ropes, Ltd., have installed in their new wire research department a Siemens and Halske Elmiskop II electron microscope, which can resolve details only one-tenth of a millionth of one inch apart, the maximum useful magnification being about 50,000 ×.

Rope Research Department

The other half of the central research department (the rope department) is divided into six sections: (*a*) chemical analysis, (*b*) metallurgical examination, (*c*) physical testing, (*d*) fibre and synthetics' evaluation, (*e*) photographic documentation, and (*f*) development. Each of the sections is run by a section leader who is usually a senior specialist in the science concerned. Often a specific project is allocated to one section, to be dealt with in its entirety. In other cases a number of sections can be mobilised to form a project team. The junior members of the staff are all taking approved training courses at local technical colleges and will, in the course of time, upgrade to graduates. The company has also inaugurated its own trainee scheme within the department so that there will be two sources of supply for filling senior positions in the future.

The work of the rope research department is split up as follows:—

The chemical analysis section carries out general chemical and metallurgical analyses, but also specialises in laboratory studies of rope lubricants and dressings, plus the all-important subject of corrosion and its prevention. It is also largely responsible for the preparation and examination of samples from the marine testing station in Norfolk.

The metallurgical section works closely with the physical testing section on the metallurgical aspects of fatigue in ropes, and with the chemical analysis section on corrosion. It also undertakes specific research projects such as a study of the factors which influence the stress corrosion of high tensile copper-nickel wire.

The physical testing section tests wires, strands and ropes for physical characteristics such as ultimate tensile strength (up to 100 tons load), modulus of elasticity, etc. This section also carries out pulsatory and reverse bend fatigue tests, and studies and evaluates lubricants.

The fibre and synthetics section deals particularly with the chemical and physical evaluation of rope cores, with special reference to synthetics, and also carries out laboratory and field tests of microbial agents and rot-proofing.

Avery 12,000 lb. capacity tensile testing machine fitted with electrical extensometer and recording system.

The work of the photographic and development section is self evident.

Equipment of the rope research department is extensive and varied, and includes a Zeiss photo-micrographic unit, capable of examining specimens by transmitted or reflected light at magnifications up to 4,400 ×; a 100-ton capacity Amsler universal pulsatory fatigue testing machine, capable of applying static and dynamic loads to ropes of up to 2¼ in. diameter; a Watson stereoscopic microscope with camera attachments; and a Denison 15-ton capacity hydraulically operated tensile machine.

Space does not permit a comprehensive account of the equipment and activities of the central research department, but the foregoing gives some indication of the importance the company attaches to research, in that no expense appears to have been spared to ensure that the staff should have the best of equipment at its disposal.

Order for Standard Furnaces

It is the nature of things in general that only the large specially designed and produced equipments are considered fit subjects for publicity, while the steady sale of standard units passes by unheralded. Yet the policy of Wild-Barfield Electric Furnaces, Ltd., of Watford Herts., in producing standardised units whenever possible ensures that a wide range of heat treatment equipments is available to industry at comparatively short delivery times, an advantage when delays in installation of new plant may prove costly. An order for six such units has recently been received from Samuel Fox & Co., Ltd., and there is, in addition, a seventh equipment that will be a modified standard furnace. The order calls for three forced air circulation and three horizontal batch type furnaces with a special high temperature equipment, and such is the advantage of standardized production that commencement of delivery could be effected in a few weeks.

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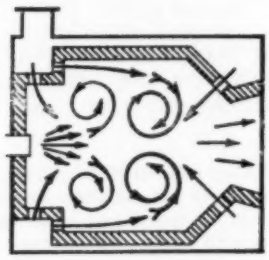

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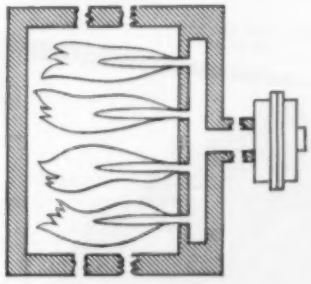

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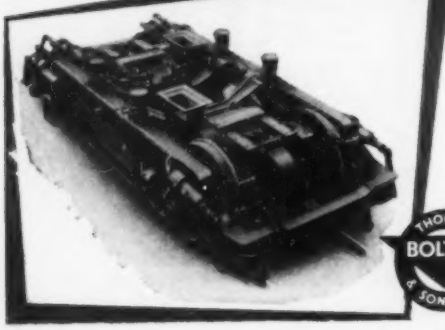

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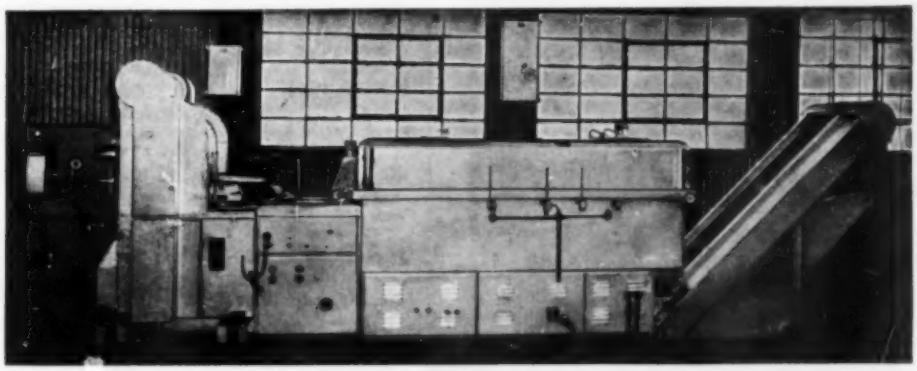

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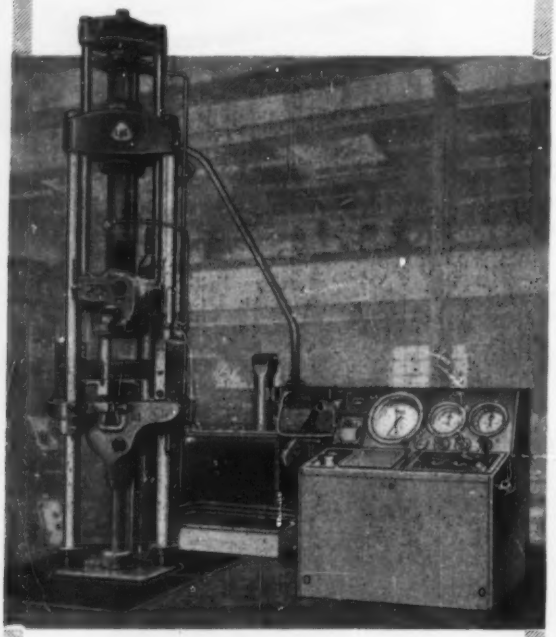

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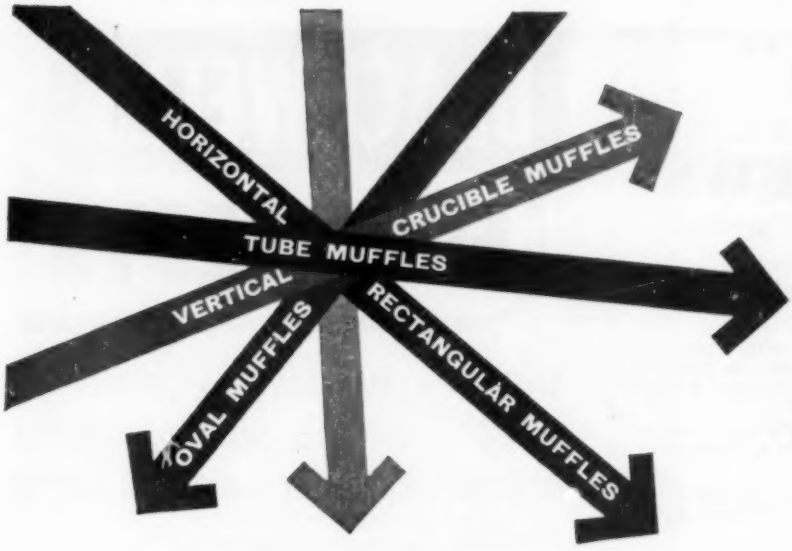

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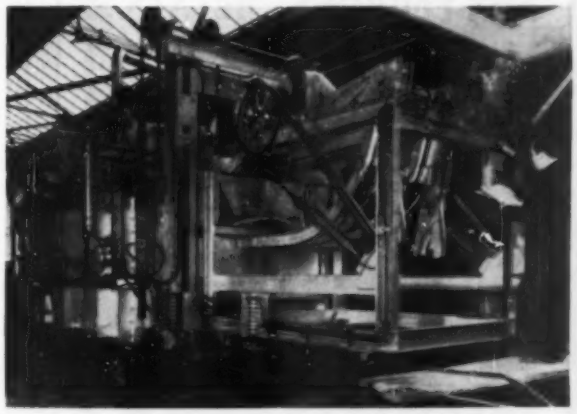

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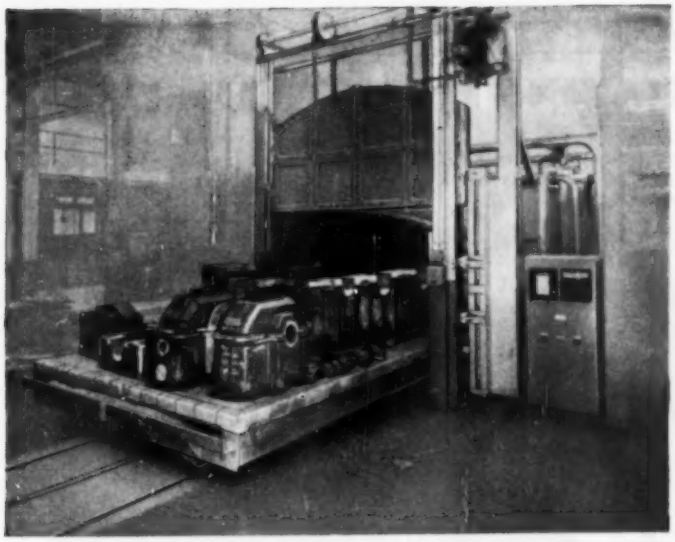

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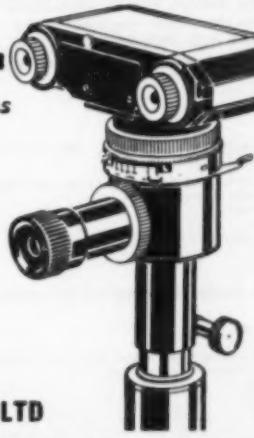

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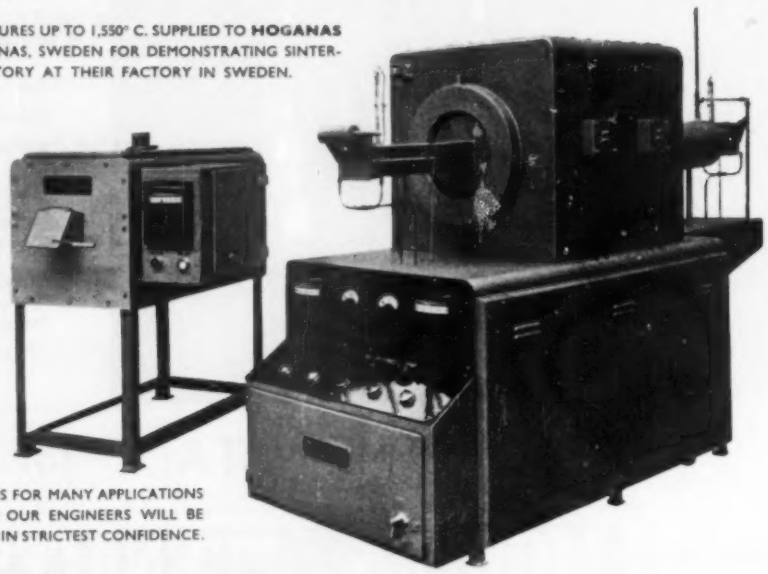

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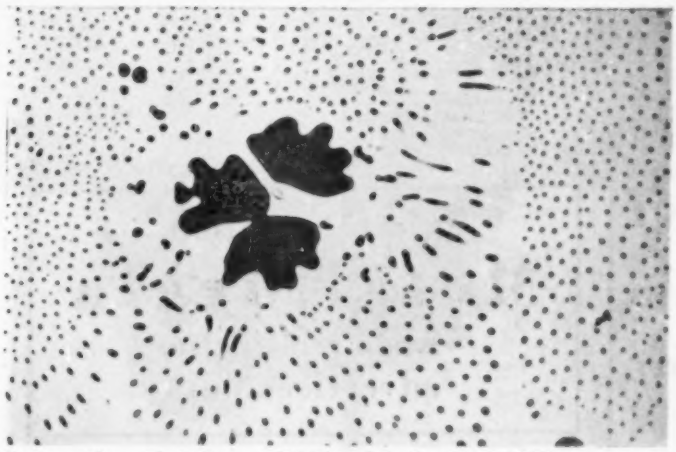

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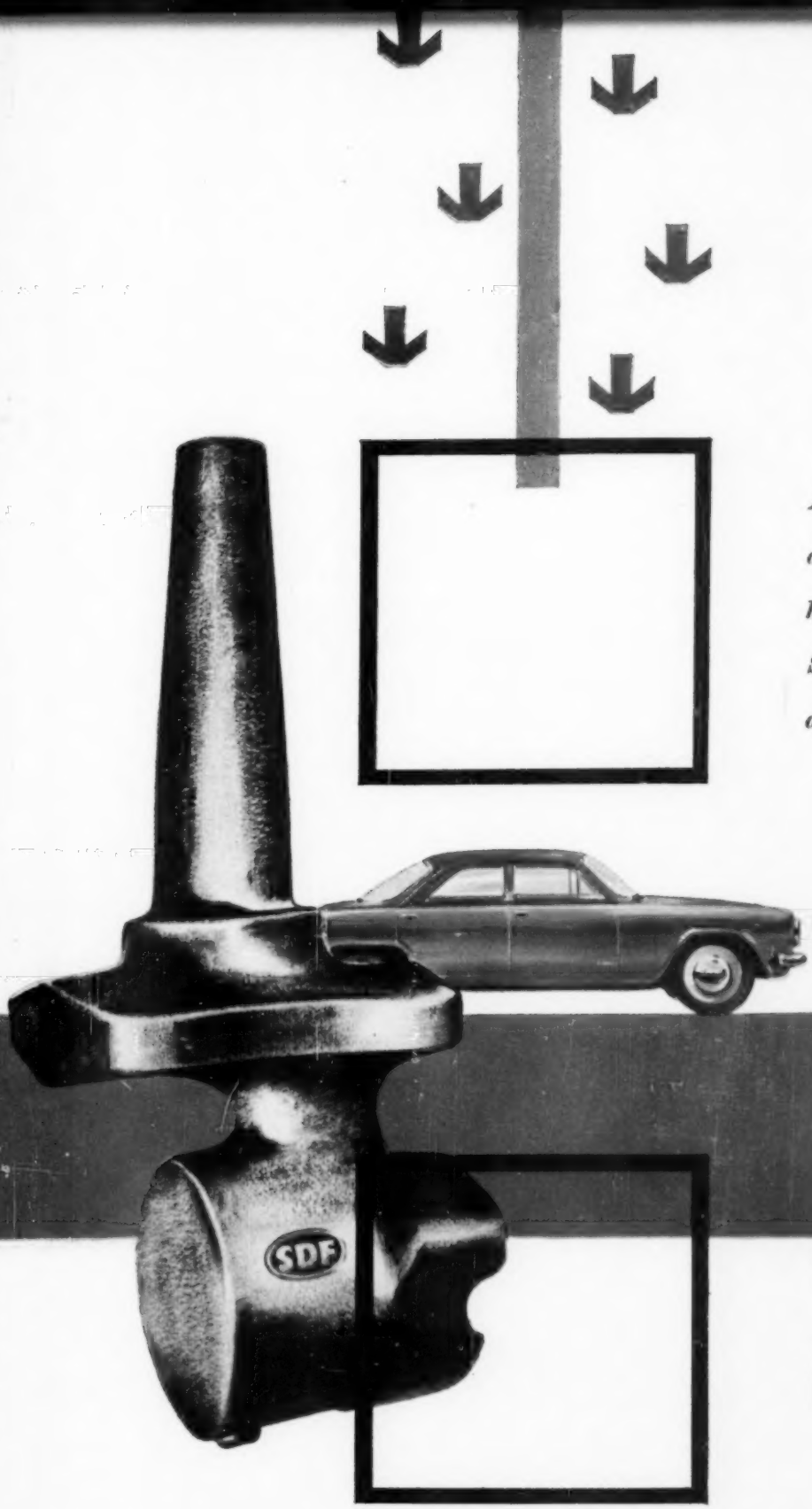

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